HART

SA's premier cropping field site

Trial Results 2018

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The board of the Hart Field-Site Group Inc would like to acknowledge the significant financial contribution of our committed sponsors, supporters, collaborators and partners.

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We also receive project funding support provided by the Australian Government

Collaborators

Hart Events 2019

HART FIELD DAY

September 17

Our main Field Day attracts over 600 visitors from all over the South Australia and interstate.

Every half hour a block of eight sessions are run simultaneously with highly regarded specialists speaking at each trial. A comprehensive take-home Field Day Book included in the entry fee.

This is Hart's main event of the year.

HART

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Hart AGM

April 9

6pm, Blyth Hotel

Getting The Crop In

March 13

8am – 12:15pm

Industry guest speakers from across the county cover a wide range of topics, all relevant to broadacre cropping.

Winter Walk

July 16

9am – 12pm

An informal guided walk around the trial site; the first opportunity to inspect the site post seeding, with guest speakers presenting their observations on current trials.

They are on hand to answer questions and will also share their knowledge on all the latest cropping systems and agronomic updates.

Spring Twilight Walk

October 15

5pm followed by BBQ

Another informal opportunity to inspect the trial site, this time just prior to harvest, again with industry researchers & representatives presenting in the field.

This event is followed by drinks and a BBQ in the shed - a great opportunity to network.

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We would also like to thank various organisations for the provision of seed and/or products that were trialed in the 2018 research program.

ADAMA
Advanta Seeds
Australian Grain Export
Australian Grain Technologies
BASF
Bayer Crop Science
Corteva Agriscience
Crop Care
Heritage Seed
Imtrade
Incitec Pivot
InterGrain
Longreach Plant Breeders
Nufarm
Nuseed
Pasture Genetics
Pioneer Seeds
Pulse Breeding Australia
Seednet
Seed Force
Syngenta

Partners

Blyth Revegetation Committee, Mid-North Grasslands Working Group, Wakefield Regional Council

Site Management

SARDI, New Variety Agronomy Clare:
John Nairn, Phil Rundle, Sarah Day, Christine Walela, Dili Mao, Richie Mould, Patrick Thomas, Navneet Aggarwal, Penny Roberts, Dylan Bruce

SARDI, New Variety Agronomy Waite:
Kenton Porker

SARDI, New Variety Agronomy Pt Lincoln:
Andrew Ware

Hart Field-Site Group:
Sarah Noack & Emma Pearse

Our guiding principles

OUR PURPOSE

To deliver value to growers and make agriculture better

OUR VISION

To be SA's premier cropping field site, providing independent information and skills to the agricultural industry

OUR VAULES

Independence

in order to provide unbiased results

Relevance

to issues facing farmers

Integrity

in all dealings

Credibility

through providing reliable, quality information

Professionalism

in the management of the site and presentation of trials

Value for money

low cost of information to farmers

Hart management

Hart Field-Site Group board

Damien Sommerville (Spalding)..Chairman, sponsorship
Ryan Wood (Clare)..Vice chairman
Sandy Kimber (Clare) ....Executive officer
Deb Purvis (Farrell Flat) ....Finance officer
Matt Dare (Marola) ....Commercial crop manager, sponsorship
Justin Wundke (Condowie) ....Sponsorship
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Simon Honner (Blyth) ....Board member
Alex Thomas (Torrens Park) ....Board member

Sarah Noack..Research & extension manager
Emma Pearse...Regional intern
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Or find out more about us…

Are you passionate about broadacre agriculture?

Apply now to join the Hart board

Nominations from local growers are particularly encouraged but we value diversity and all applications are welcome

*nominations close 5pm April 9, 2019

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Find out more

www.hartfieldsite.org.au

or give us a call, we'd love to hear from you

Damien Sommerville, Chairman 0417 850 587

Sandy Kimber, Executive Officer 0427 423 154

The 2018 season at Hart

The Mid-North had a dry start to seeding and Hart was no exception. With well below average summer rainfall this also meant there was limited stored moisture available going into the season. Trial seeding commenced on the 20th March, well before our traditional sowing window and the final trials were sown on the 4th June. Trial plots sown prior to the beginning of May were irrigated to achieve germination and establishment.

The majority of Hart's research program was sown in mid-May. The site received less than average (28 mm) rainfall during April with a total of 13 mm. We recorded 42 mm of rain throughout May which improved seed bed moisture and reduced moisture stress in the early sown trials.

From June onwards, we received well below average rainfall for the remainder of the growing season (Figure 1). Due to the drier than normal conditions the trials progressed quickly however, lack of spring rainfall reduced grain yields. Rain events in November (Table 1) were too late to effect grain yield and delayed harvest and hay baling.

In total Hart received 224 mm of annual rainfall (average 400 mm) and 160 mm of growing season rainfall (average GSR 300 mm). This put 2018 in the lowest 10% of rainfall records (decile 1). More recently this growing season rainfall compares to 2006 and 2012 which received 138 mm and 168 mm, respectively.

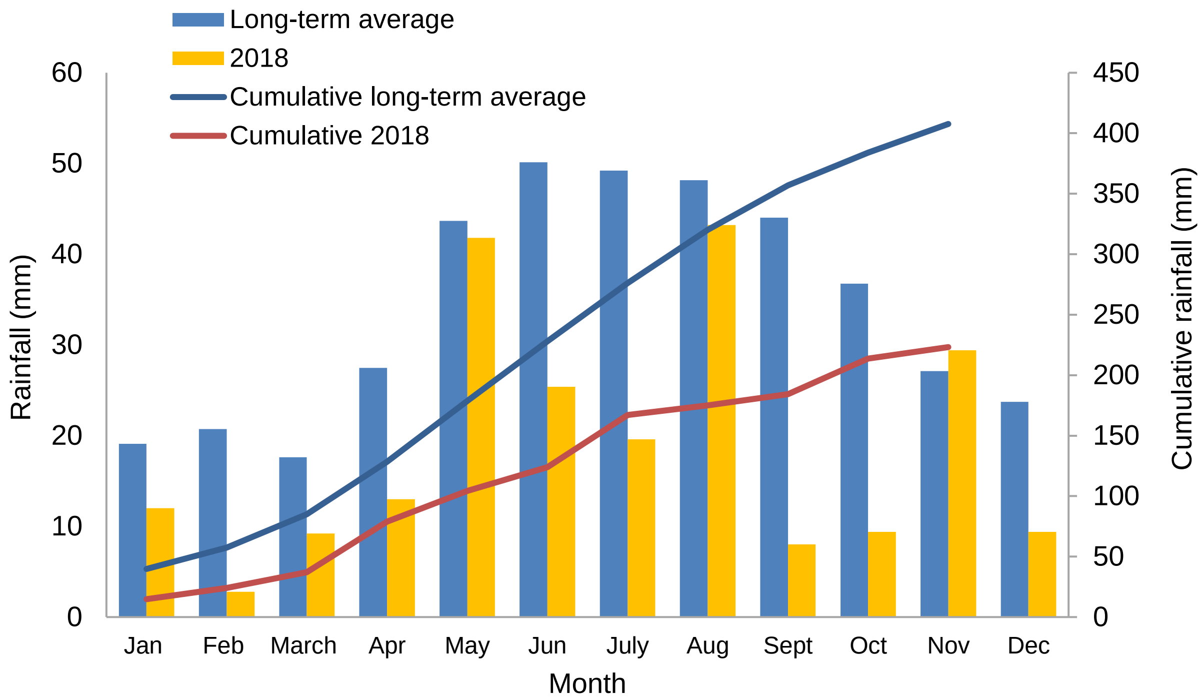

Figure 1. Hart rainfall (mm) for 2018 and long-term (100 years of rainfall records) average. The cumulative rainfall is presented as lines for 2018 (blue) and the long-term average (orange).

Table 1. Hart rainfall chart 2018 (Hart weather station).

	January	February	March	April	May	June	July	August	September	October	November	December
1							0.2		3.6			1.0
2	0.4							1.6	0.6	2.4	0.6	
3					17.2			11.4		0.6		
4					2.2						8.4	
5								1.2			3.2	
6											0.4	
7						3.4	1.4	0.2			0.6	
8						3.6				2.4		
9					0.6	3.8		0.6		0.4		
10					3.0			9.2				
11					5.6	0.6	1.6	2.4				
12	3.2					0.2	2.2	3.0				
13						1.2		0.2			0.4	2.4
14					0.2	4.6		0.2		1.4		6.0
15				0.6		2.4			1.6			
16			5.6	6.2		4.4		0.2		2.0		
17				2.4						0.2		
18		2.6	0.6	2.2	2.8			1.4				
19					0.2		7.0		1.0			
20			0.8				3.0		1.2		4.4	
21											4.2	
22											1.0	
23							0.6					
24		0.2		1.6			0.0				2.6	
25			2.2									
26							0.2					
27					5.6		0.6				3.6	
28	8.4				4.4		0.8					
29						1.0	2.0					
30						0.2		3.6				0.6
31								8.0				
Montly total	**12.0**	**2.8**	**9.2**	**13.0**	**41.8**	**25.4**	**19.6**	**43.2**	**8.0**	**9.4**	**29.4**	**10.0**
GSR rainfall				13.0	54.8	80.2	99.8	143.0	151.0	160.4		
Total rainfall	12.0	14.8	24.0	37.0	78.8	104.2	123.8	167.0	175.0	184.4	213.8	223.8

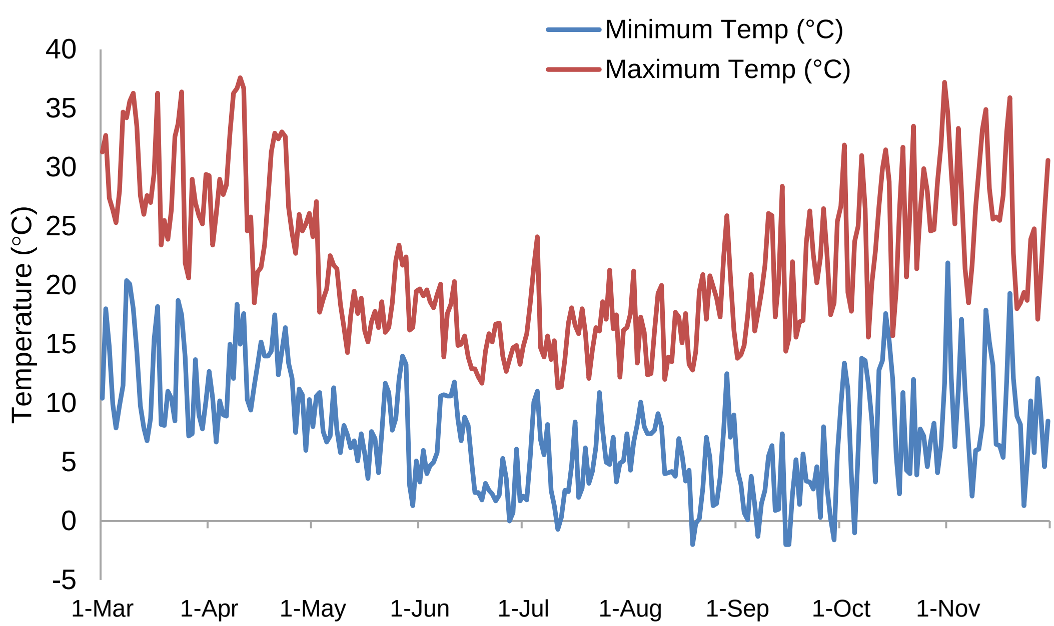

Figure 2. Daily maximum and minimum air temperature at Hart, 2018.

Table 2. General soil physical and chemical properties for the Hart field site. Sampled on 16th April, 2018.

		Sampling depth (cm)					
Soil property	Units	0-15	15-35	35-55	55-75	75-105	Total profile
Texture							Loam – clay loam
Gravel	%	0	0	0	0	0	
Phosphorous Colwell	mg/kg	26	9	8	2	2	
Potassium Colwell	mg/kg	335	250	253	305	220	
Available soil nitrogen	kg/ha	25	34	16	5	6	86
Sulphur	mg/kg	4	5	20	56	125	
Organic carbon	%	1.2	0.8	0.7	0.4	0.3	
Conductivity	dS/m	0.2	0.3	0.4	0.8	0.7	
pH ($CaCl_2$)		7.6	8	8.1	8.5	8.4	

Booleroo Centre rainfall 2018

Booleroo Centre 2018 rainfall chart (source Booleroo Centre BOM weather station)

	January	February	March	April	May	June	July	August	September	October	November	December
1									6.4			7.8
2									0.4			
3					2.4			9	1.6	0.4		
4					9.4			0.8		0.2		
5								0	0.2		2	
6								2.8			15.6	
7							1.4	0.6			0	
8						11	2	1.4			1	
9						13				0.8		
10					1.8					1.2		
11					0.1			9				
12						1.6		1.8	0.2			4
13	0.6					0.2		0.4			0.6	1
14						1.4						0.0
15				5		3.8				3.6		1.8
16				1.6		0.6			1	0.4		1
17				0.6		2.4				1.4		
18			0.4					0.6				
19		2.2			1.2							
20					1	0.4	5.4		0.4	0.2		
21					0.2						0.4	
22												
23							0.4					
24		0.6					0.4	0.4				
25		0.2		5.6							9.6	
26			1.6								5.6	
27							2.4				2.2	
28					9.4		0.6			3		
29							0.8			2.4		1
30	7					1						0.2
31								10.8				
Montly total	**7.6**	**3.0**	**2.0**	**12.8**	**25.5**	**35.4**	**13.4**	**37.6**	**10.2**	**13.6**	**37.0**	**16.8**
GSR rainfall				12.8	38.3	73.7	87.1	124.7	134.9	148.5		
Total rainfall	7.6	10.6	12.6	25.4	50.9	86.3	99.7	137.3	147.5	161.1	198.1	214.9

Washpool rainfall 2018

Washpool 2018 rainfall chart (source Spalding BOM weather station)

	January	February	March	April	May	June	July	August	September	October	November	December
1									3.6			0.0
2	4								7.8			1.4
3					2.2			7		0.4		
4					18.4			2				
5					0.2						0.4	
6							1.6	5			21.6	
7							2.2	5			1.2	
8					0.6	11.8		0.8			2.8	
9						3.2				1		0.2
10					1.8					0.2		0.2
11					4.6			16				
12					2.2	0.6	0.8	1.0	1			
13	2					1	2	2.4				2
14						1.6						3.8
15				7.6		5				1.2		0.4
16				5.8		5			2.2	1.4		
17				0.4		2				3.8		
18			1.2			0.2		0.8		0.6		
19		2.4			3			0.6				
20					0.4		20.2		2			
21				0.8			4				2.8	
22											13.0	
23												
24							1.2					
25		0.2	2.4	0.6							2.8	
26			1.4									
27											1	
28					8.2						1	
29	1.6				1.6		5.4					1.2
30	13.6				0.2	3	1.4					
31								5.0				
Montly total	**21.2**	**2.6**	**5.0**	**15.2**	**43.4**	**33.4**	**38.8**	**45.6**	**16.6**	**8.6**	**46.6**	**9.2**
GSR rainfall				15.2	58.6	92.0	130.8	176.4	193.0	201.6		
Total rainfall	21.2	23.8	28.8	44.0	87.4	120.8	159.6	205.2	221.8	230.4	277.0	286.2

Interpretation of statistical data

The results of replicated trials are presented as the average (mean) for each of the replicates within a treatment.

Authors generally use ANOVA, in which the means of more than one treatment are compared to each other. The least significant difference (LSD P≤0.05), seen at the bottom of data tables gives an indication of the treatment difference that could occur by chance. NS (not significant) indicates that there is no difference between the treatments. The size of the LSD can be used to compare treatment results and values must differ by more than this value for the difference to be statistically significant.

So, it is more likely (95%) that the differences are due to the treatments, and not by chance (5%). Of course, we may be prepared to accept a lower probability (80%) or chance that two treatments are different, and so in some cases a non-significant result may still be useful.

Interpretation of replicated results: an example

Here we use an example of a replicated wheat variety trial containing yield and grain quality data (Table 1). Statistically significant differences were found between varieties for both grain yield and protein. The LSD for grain yield of 0.40 means there must be more than 0.40 t/ha difference between yields before that varieties performance is significantly different to another. In this example Trojan is significantly different to all other varieties as it is the only variety followed by a superscript (a). Scout, Mace and Cosmick are not significantly different from each other and are all followed by a superscript (b) as they all yielded within 0.4 t/ha of each other.

Similarly, for grain protein a varieties performance was significant from another if there was more than 0.9% difference in protein. In the example, Arrow contained a higher protein level compared to all other varieties which were not different to one another.

Where there are no significant differences between treatments, NS (not significant) will be displayed as seen in the screenings column (Table 1).

Table 1. Wheat variety grain yield, protein and screenings from a hypothetical example to illustrate interpretation of LSD.

Variety	Grain yield (t/ha)	Protein (%)	Screenings (%)
Arrow	3.50^{c}	10.3^{a}	0.2
Cosmick	3.98^{b}	8.4^{b}	1.0
Mace	3.75^{bc}	9.1^{b}	0.5
Scout	4.05^{b}	8.9^{b}	0.9
Trojan	4.77^{a}	8.4^{b}	0.4
LSD (P≤0.05)	0.40	0.9	NS

Disclaimer

While all due care has been taken in compiling the information within this manual the Hart Field-Site Group Inc or researchers involved take no liability resulting from the interpretation or use of these results.

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Comparison of wheat varieties

Emma Pearse & Sarah Noack, Hart Field-Site Group

Key Findings

- There were a number of high yielding (2.21 – 2.41 t/ha) AH varieties at Hart in 2018 including, Scepter, Grenade CL Plus, Scout, Hatchet CL Plus, Emu Rock, Beckom and Arrow.
- Cutlass and Trojan were the highest yielding APW varieties at 2.50 and 2.25 t/ha, respectively.
- Grain test weight and screening levels across all varieties averaged 78.9 kg/hL and 2.0%.

Why do the trial?

To compare the performance of new wheat varieties against the current industry standards.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + Zn + Impact @ 80 kg/ha
Seeding date	14th May 2018		UAN (42:0) @ 60 L/ha on 17th July
			UAN (42:0) @ 55 L/ha on 2nd August

This trial was a randomised complete block design with three replicates and 20 wheat varieties. Herbicides were applied as necessary to keep the crop free of weeds. All plots were assessed for grain yield, protein, test weight, and screenings with a 2.0 mm screen.

Results and discussion

For the 2018 season, Hart received well below average growing season rainfall (160 mm). Low summer rainfall also resulted in limited soil moisture available pre-seeding. Wheat grain yields ranged from 1.81 t/ha for Havoc up to 2.50 t/ha for Cutlass at Hart (Table 1). The highest yielding (2.21 – 2.41 t/ha) AH varieties included, Scepter, Grenade CL Plus, Scout, Hatchet CL Plus, Emu Rock, Beckom and Arrow. Both Cutlass and Trojan were the highest yielding APW varieties at 2.50 and 2.25 t/ha, respectively.

Long-term yield data shows Scepter, Trojan and Cutlass continue to perform well at Hart over a number of seasons (Table 2).

Wheat grain protein levels ranged from 10.4% (Cutlass) to 12.6% (Cobra), with a site average of 11.5%. While no hard varieties met the minimum protein for H1 classification, all but Arrow, Cosmick, Scepter and Scout, met the minimum protein requirement for H2 (11.5%). All varieties contained >10.5% protein to meet the minimum requirement for APW1 classification (with the exception of Cutlass at 10.4%).

Grain test weights averaged 78.9 kg/hL across all wheat varieties. DS Pascal was the only variety under the minimum requirement of 76 kg/hL at 75.4 kg/hL. Screening levels averaged 2.0% across the trial, with all varieties below the 5% maximum for Hard and APW classification.

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%) of wheat varieties at Hart in 2018.

Quality	Variety	**Grain yield** t/ha	% of site average	**Protein** %	% of site average	**Test Weight** kg/hL	% of site average	**Screenings** %	% of site average
AH	Arrow	2.18	102	10.8	94	80.0	101	1.5	72
	Beckom	2.21	104	12.0	104	79.2	100	1.5	72
	Cobra	2.05	96	12.6	109	77.6	98	1.9	92
	Cosmick	2.09	98	10.6	92	78.5	99	3.2	158
	Emu Rock	2.22	104	11.7	102	78.7	100	2.1	103
	Grenade CL Plus	2.35	110	11.6	101	78.4	99	1.8	87
	Hatchet CL Plus	2.25	106	12.1	105	80.7	102	1.7	85
	Havoc	1.81	85	12.3	106	78.5	100	2.9	144
	Kord CL Plus	2.13	100	12.1	105	78.9	100	2.5	123
	Mace	2.02	95	12.3	106	78.0	99	1.8	89
	Scepter	2.41	113	10.7	93	80.1	101	2.8	136
	Scout	2.27	107	11.4	99	77.4	98	1.7	81
	H1 receival standard			>13.0		>76		<5.0	
APW	Chief CL Plus	1.86	87	12.0	104	79.5	101	1.8	89
	Corack	1.84	86	12.0	104	79.0	100	1.7	85
	Cutlass	2.50	117	10.4	90	81.1	103	1.7	81
	DS Pascal	1.83	86	11.9	103	75.4	95	3.2	156
	Estoc	2.12	100	12.3	106	79.3	100	1.7	84
	Trojan	2.25	106	10.8	93	80.5	102	1.5	72
	APW1 receival standard			>10.5		>76.0		<5.0	
ASW	Razor CL Plus	2.21	104	10.6	92	79.1	100	2.1	102
	ASW1 receival standard			NA		>76		<5.0	
Unclassified	RAC2388	2.27	107	10.7	93	78.2	99	1.8	89
	Site Average	2.13	100	11.5	100	78.9	100	2.0	100
	LSD (P≤0.05)	0.33		0.35		1.22		0.46	

Table 2. Wheat variety performance at Hart by year (expressed as % trial average).

		% of trial average					
Quality	**Variety**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
AH	Arrow			105	98	103	102
	Beckom					112	104
	Cobra	110	108	104	105	100	96
	Cosmick		105	105	101	97	98
	Emu Rock	107	103	100	99	98	104
	Grenade CLPlus	95	93	102	96	95	110
	Hatchet CLPlus	104	82	51	88	86	106
	Havoc					97	85
	Kord CLPlus	96	94	97	90	97	100
	Mace	116	105	100	94	102	95
	Scepter			110	106	111	113
	Scout	110	102	110	103	107	107
APW	Corack	109	115	95	96	86	86
	Chief CL Plus						87
	Cutlass			104	119	104	117
	DS Pascal					90	86
	Estoc	106	100	104	108	96	100
	Trojan		108	113	121	113	106
ASW	Razor CLPlus					103	104
Unclass	RAC2388					108	107
	Trial mean yield t/ha	**4.07**	**4.8**	**4.27**	**3.87**	**3.83**	**2.13**
	Sowing date	18th May	8th May	6th May	10th May	8th May	14th May
	A-O rain (mm)	303	280	230	356	191	160
	Annual rain (mm)	377	426	353	485	331	224

Comparison of barley varieties

Emma Pearse & Sarah Noack, Hart Field-Site Group

Key Findings

- Barley grain yields ranged from 2.54 – 3.11 t/ha, with a trial average of 2.86 t/ha.
- A range of feed and malt varieties performed well in a below average rainfall season (160 mm growing season rainfall at Hart).
- Test weight, protein and screening levels across all malt varieties were good, averaging 70 kg/hL, 10.7% and 1.6%, respectively.

Why do the trial?

To compare the performance of new barley varieties against the current industry standards.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + Zn + Impact @ 60 kg/ha
Seeding date	14th May 2018		UAN (42:0) @ 60 L/ha on 17th July
			UAN (42:0) @ 55 L/ha on 2nd August

This trial was a randomised complete block design with three replicates and 15 barley varieties. Fungicides and herbicides were applied as necessary to keep the crop canopy free of disease and weeds. All plots were assessed for grain yield, protein, test weight, and screenings with a 2.2 mm screen and a 2.5 mm screen.

Results and discussion

The highest yielding malt variety at Hart was Compass (3.01 t/ha), followed by Commander and Charger both yielding 2.98 t/ha (Table 1). Banks and RGT Planet are currently undergoing malt accreditation and also performed well this season, with grains yields of 2.94 and 2.78 t/ha, respectively. Spartacus CL was the higher yielding CL malt variety (2.80 t/ha) compared to Scope (2.54 t/ha). Feed variety yields ranged between 2.86 – 3.11 t/ha, with Fathom the highest yielding.

The long-term yield data shows feed varieties Fathom, Fleet and Keel continue to perform well across a range of seasons at Hart (Table 2). Within the malt varieties there is greater variation in the long-term yields. In general Compass and LaTrobe have performed well at Hart across a number of seasons.

Grain protein only varied by 1.3% across all varieties ranging from 10.1 – 11.4%. The site grain protein levels for malting varieties averaged 10.7%, in the range to achieve malt 1 classification. All test weights for feed and malt varieties were above the minimum 62.5 and 65 kg/hL, respectively.

Screenings were low across all varieties, averaging 1.8%. Retention levels ranged from 70.9 – 92.2%, all above the 70% minimum for malt 1 classification. Banks was the only variety to have a retention less than 70% (57.8%).

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL), screenings and retention (%) of barley varieties at Hart 2018.

Quality	Variety	Grain yield t/ha	% of site average	Protein %	% of site average	Test weight kg/hL	% of site average	Screenings %	% of site average	Retention %	% of site average
Feed	Fathom	3.11	109	10.6	98	67.9	97	1.0	54	93.8	112
	Fleet	3.03	106	11.4	105	66.4	95	1.1	63	97.7	117
	Hindmarsh	2.86	100	10.4	97	70.6	101	1.7	94	85.8	102
	Keel	2.99	105	10.3	96	69.1	99	3.2	178	86.3	103
	Rosalind	2.92	102	10.8	100	68.7	99	2.3	124	87.3	104
F1 Receival Standards				NA		>62.5		<15%		NA	
Malting	Charger	2.98	104	10.7	99	68.5	98	1.7	91	81.8	98
	Commander	2.98	104	10.6	98	68.4	98	2.1	113	84.5	101
	Compass	3.01	105	10.1	94	69.7	100	1.0	55	92.2	110
	GrangeR	2.55	89	11.2	103	71.2	102	2.5	138	70.9	85
	LaTrobe	2.83	99	10.5	97	70.8	102	1.4	79	87.4	104
	Navigator	2.74	96	10.7	99	69.7	100	1.3	73	82.5	98
	Scope	2.54	89	11.2	103	70.6	101	1.3	70	88.8	106
	Spartacus CL	2.80	98	11.2	103	70.9	102	1.8	101	82.7	99
Malt 1 Receival Standards				9-12%		>65		<7%		>70%	
pending malt accreditation	Banks	2.94	103	11.2	104	72.1	103	3.4	186	57.8	69
	RGT Planet	2.78	97	11.3	104	71.0	102	1.6	90	78.0	93
Site Average		2.86	100	10.81	100	69.7	100	1.82	100	83.83	100
LSD (P≤0.05)		0.36		0.36		1.22		0.98		10.92	

Table 2. Barley variety performance at Hart by year (expressed as % trial average).

		% of trial average					
Quality	**Variety**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Feed	Fathom	109	113	112	104	94	109
	Fleet	103	106	107	100	104	106
	Hindmarsh	110	103	108	92	98	100
	Keel	107	112	112	97	102	105
	Rosalind				104	91	102
Malt	Charger	99	106	105	114	97	104
	Commander	104	105	100	92	102	104
	Compass	109	111	111	86	106	105
	GrangeR	100	108	93	103	108	89
	La Trobe	109	105	107	94	104	99
	Navigator	99	101	92	113	111	96
	Schooner	89	87	100	73	49	
	Scope	95	97	99	94	89	89
	Spartacus CL			106	95	98	98
Pending malt acc	Banks						103
	RGT Planet					134	97
	Mean yield (t/ha)	**5.03**	**4.74**	**4.38**	**4.62**	**4.36**	**2.86**
	Sowing date	18th May	15th May	6th May	10th May	8th May	14th May
	April - Oct (mm)	303	280	230	356	191	160
	Annual rainfall (mm)	377	426	353	485	331	224

Comparison of durum varieties

Emma Pearse, Hart Field-Site Group

Key findings

- The average grain yield for all durum varieties at Hart was 2.31 t/ha, not yielding significantly different.
- Grain protein levels were moderate (trial average 11.6%), while screenings and test weights were good averaging 2.5% and 77.9 kg/hL, respectively.

Why do the trial?

To compare the performance of new durum varieties against the current industry standards.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + Zn + Impact @ 80 kg/ha
Seeding date	15th May 2018		UAN (42:0) @ 60 L/ha on July 17th
			UAN (42:0) @ 55 L/ha on August 2nd

This trial was a randomised complete block design with three replicates and 7 durum varieties. Herbicides were applied as necessary to keep the crop free of weeds. All plots were assessed for grain yield, protein, test weight, and screenings with a 2.0 mm screen.

Results and discussion

Durum yields ranged from 2.08 t/ha (Saintly) to 2.45 t/ha (WID802) with a site average of 2.31 t/ha (Table 1). There was little difference (0.12 t/ha) between the highest yielding durum varieties; WID802, DBA Vittaroi, DBA Spes, DBA Aurora and SSD1476-067. The long-term data shows a range of durum varieties (DBA Aurora, Tjilkuri and Yawa) have generally performed well in terms of grain yield, across a number of seasons (Table 2).

Grain protein levels ranged from 10.7% to 12.5% with all but DBA Aurora, DBA Vittaroi and WID802 meeting the 11.5% receival standard for DR2 classification. No durum varieties trialed met the 13% standard for DR1 classification.

Grain test weights ranged from 76.2 to 79.5 kg/hL, all meeting the minimum test weight value of 76 kg/hL for DR1 (Table 1). Screening results were all below the 5% requirement for DR1, ranging from 1.1% (DBA Vittaroi) to 4.7% (SSD1476-067).

Table 1. Grain yield (t/ha), protein (%), test weight (kg/hL) and screenings (%) for durum varieties at Hart in 2018.

Variety	Grain yield t/ha	% of site average	Protein %	% of site average	Test weight kg/hL	% of site average	Screenings %	% of site average
DBA Aurora	2.35	102	11.2	97	78.1	100	1.4	55
DBA Vittaroi	2.41	104	11.2	97	79.5	102	1.1	44
Hyperno	2.19	95	12.0	104	78.7	101	4.4	173
Saintly	2.08	90	12.5	108	78.1	100	1.4	54
SSD1476-067	2.32	101	11.6	101	76.2	98	4.7	184
DBA Spes (UAD1154192)	2.37	102	11.6	100	77.6	100	2.0	80
WID802	2.45	106	10.7	92	77.4	99	2.8	110
DR1 receival standards			≥13.0		>76		<5%	
Site Average	2.31	100	11.6	100	77.9	100	2.5	100
LSD (P≤0.05)	0.15		0.83		0.78		0.64	

Table 2. Durum wheat variety performance at Hart by year (expressed as % trial average).

	% of trial average					
Variety	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
DBA Aurora		100	105	102	100	102
DBA Vittaroi						104
Hyperno	95	97	98	101	96	95
Saintly	105	97	97	85	100	90
Tamaroi	100	98	94	98	103	
Tjilkuri	101	102	102	109	100	
WID802	100					106
Yawa	100	107	105	116	104	
SSD1476-067						101
DBA Spes (UAD1154192)						102
Trial mean yield t/ha	**3.73**	**4.23**	**3.07**	**4.08**	**4.24**	**2.31**
Sowing date	18th May	8th May	6th May	10th May	9th May	15th May
A-O rain (mm)	303	280	230	356	191	160
Annual rain (mm)	377	426	353	485	331	224

Managing early sown long season wheats – results from the Mid-North

Sarah Noack[1] Kenton Porker[2], and James Hunt[3]
Hart Field-Site Group [1], SARDI[2] and La Trobe University[3]

Key Findings

- Winter wheats sown early (pre-April 20) were able to yield similar to Scepter sown in its optimal window.
- Different winter wheats are required for different environments.
- At Hart, the fast – mid developing variety Illabo has been the highest yielding winter wheat across two seasons.

Why do the trial?

The time at which wheat flowers is very important in determining yield. Crops that flower too early have increased risk of frost damage and insufficient biomass, while crops which flower too late have increased risk of high temperatures and water stress which can restrict grain formation and grain-filling. As autumn breaks are declining in frequency and magnitude in the southern grains region, and the size of farming enterprises are increasing, getting a wheat crop established so that it flowers during the optimal flowering period for peak yield can be difficult. However, an opportunity exists in South Australia to take advantage of stored moisture over the summer and rain events in March and April to start sowing crops earlier than what is currently practiced.

Over the last few decades wheat breeding efforts have focused on mid-fast developing spring varieties (for example Scepter) that need to be sown in the first half of May to flower during the optimal period (late September for Hart) for grain yield. Sowing earlier than April 20 requires winter varieties that are slower developing. The ability to sow wheat outside our traditional window opens up opportunities to improve whole farm yield and manage risk.

Breeders have responded to this change in farming system and are now developing material suited to earlier sowing. Previous research has shown that winter varieties (e.g. Wedgetail and Rosella) bred for NSW are not suited to SA conditions. This project compares performance of new winter wheats sown early compared to current spring benchmarks sown on time.

How was it done?

Location: Hart *(rainfall refer to page 11)*

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + 2% Zn @ 75 kg/ha UAN (42:0) @ 60 L/ha on 5th July UAN (42:0) @ 55 L/ha on 2nd Aug
Seeding date	20th March (irrigated) 3rd April (irrigated) 14th April (irrigated) 1st May		

Location: Booleroo Centre *(rainfall refer to page 12)*

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + 2% Zn @ 75 kg/ha
Seeding date	21st March (irrigated) 4th April (irrigated) 18th April (irrigated) 2nd May (irrigated)		

At each location the trial was a split plot design with four replicates of nine varieties (Table 1) at four times of sowing. Where irrigation was required the equivalent of 10 mm rainfall was applied using dripper line in-furrow post-seeding to ensure germination. Fungicides and herbicides were applied as necessary to keep the canopy free of disease and weeds.

All plots were assessed for plant establishment, heading date, grain yield and quality (except Booleroo due to insufficient grain sample for processing).

Table 1. Summary of winter varieties, including Wheat Australia quality classification and disease based on the 2019 SA Crop Sowing Guide.

Cultivar	Release Year	Company	Development	Quality	Disease Rankings#			
					Stripe Rust	Leaf Rust	Stem Rust	YLS
Kittyhawk	2016	LRPB	Mid winter	AH	MR	MR	R	MRMS
Longsword	2017	AGT	Fast winter	Feed	RMR	MSS	MR	MRMS
Illabo	2018	AGT	Mid-fast winter	AH	RMR	S	MRMS	MRMS
DS Bennett	2018	Dow	Mid – Slow winter	ASW	R	S	MRMS	MRMS
ADV08.0008	?	Dow	Mid winter	?	-	-	-	-
ADV15.9001	?	Dow	Fast winter	?	-	-	-	-
LPB14-0392	?	LRPB	Very slow spring	?	-	-	-	-
Cutlass	2015	AGT	Mid spring	APW	MS	RMR	R	MSS
Trojan	2013	LRPB	Mid-fast spring	APW	MR	MRMS	MRMS	MSS
Scepter	2015	AGT	Fast spring	AH	MSS	MSS	MR	MRMS

Hart

Results and discussion

The trial was sown into marginal soil moisture after low summer and pre-seeding rainfall. To ensure germination would occur, the first three times of sowing were irrigated.

Plant establishment increased with seeding date from 102 plants/m^2 in mid-March to 152 plants/m^2 in early May (data not shown). All varieties performed similarly across the times of sowing, averaging 127 plant/m^2. The only variety to have reduced plant establishment (99 plant/m^2) was ADV15.9001. In other outputs of this project seeding rates of 50 and 150 plants/m^2 were compared. The main finding from this research was 50 plants/m^2 was sufficient to allow maximum yields to be achieved (Porker et al. 2019). In general, there is no yield benefit from having plant densities greater than 50 plant/m^2 for winter wheats.

Flowering time is a key determinant of wheat yield. Winter varieties are very stable in flowering date across a broad range of sowing dates, this has implications for variety choice as flowering time cannot be manipulated with sowing date in winter wheats like spring wheat. This means that different winter varieties are required to target different optimum flowering windows. The flowering time difference between winter varieties are characterised based on their relative development speed into three broad groups fast, mid-fast, mid and mid-slow for medium-low rainfall environments (Table 1 and Figure 1).

Scepter was the fastest developing spring variety, yielding 2.4 t/ha when sown at its optimal time (early May). Slower developing springs (e.g. Trojan and Cutlass) generally performed best from sowing dates after mid-April and yielded less than the best performing winter varieties when sown prior to this date. The numbered line LPB14-0392 (very slow spring) performed well at Hart again this season however has been less stable in yield and flowering date compared to winter varieties in other experiments.

A number of winter wheats sown in mid-early April were able to yield as well as Scepter sown in early May. Both ADV15.9001 and Illabo had consistent grain yields of 2.3-2.4 t/ha (Table 2). Similar to 2017 Longsword flowered earlier compared to Illabo and did not achieve the same yields (Figure 1). Longsword however, has performed well in lower rainfall areas such as Loxton and Minnipa. Both Kittyhawk and DS Bennett performed well at Hart under tough seasonal conditions but based on flowering date are slightly later than required for the Hart environment (Figure 1).

Across all environments in the project (SA and Vic), the highest yields for winter wheats generally came from early – late April establishment and results suggested that the yields may decline from sowing dates earlier than April and these dates may be too early to maximise winter wheat performance.

Grain protein levels range from 8.1 – 13.1% across all varieties and time of sowing. Changes in grain protein were generally attributed to yield dilution effects (lower yield=higher protein). DS Bennet contained the lowest protein level of all varieties, averaging 8.8% across all times of sowing. In general, majority of varieties and times of sowing were able to achieve a minimum test weight of 76 kg/hL (minimum level for AH and APW classification). In particular, Kittyhawk consistently had the highest test weight (>79 kg/hL) across all varieties. There were some exceptions, particularly for treatments sown in mid-March. Screening levels across the trial were low, with all varieties falling below the 5% level (maximum level for maximum grade).

Table 2. Grain yield and quality for all wheat varieties at different times of sowing at Hart in 2018. Treatments shaded in grey and not significantly different from the highest treatment.

Variety	Mar 20th	Apr 3rd	Apr 17th	May 1st	Mar 20th	Apr 3rd	Apr 17th	May 1st
	Grain yield (t/ha)				**Protein (%)**			
Scepter	1.3	1.8	2.1	2.4	12.5	12.2	11.9	9.5
Trojan	1.5	1.9	2.1	2.0	12.8	12.0	11.0	10.5
Cutlass	2.0	2.4	2.4	2.3	11.0	9.8	9.8	10.2
LPB14-0392	2.2	2.4	2.5	2.0	11.1	10.2	10.3	11.0
Longsword	1.8	2.2	2.0	1.9	13.1	11.8	12.2	11.8
ADV15.9001	2.3	2.4	2.3	2.1	9.7	9.3	9.1	9.3
Illabo	2.0	2.3	2.4	1.9	11.8	10.6	10.5	11.1
Kittyhawk	2.0	2.1	2.1	1.6	10.2	10.0	10.5	11.4
DS Bennett	1.9	1.9	2.2	1.5	8.5	8.8	8.1	9.9
LSD (P≤0.05)	0.24				1.1			
	Test weight (kg/hL)				**Screenings (%)**			
Scepter	75.1	75.7	76.9	78.9	2.9	2.6	3.1	3.4
Trojan	75.2	77.1	78.2	79.1	1.0	0.9	1.7	2.2
Cutlass	78.0	78.4	79.1	79.6	1.9	2.3	2.4	2.2
LPB14-0392	76.5	77.3	77.0	78.3	2.8	2.5	2.8	2.9
Longsword	76.5	78.0	77.4	78.6	1.0	0.7	0.8	1.2
ADV15.9001	76.9	77.9	77.7	78.5	3.2	2.7	3.1	2.7
Illabo	75.2	76.7	77.1	77.6	1.6	1.7	1.7	2.1
Kittyhawk	79.6	80.3	80.7	80.6	2.3	1.7	2.0	1.8
DS Bennett	78.0	78.1	79.1	78.7	3.7	3.6	3.7	3.5
LSD (P≤0.05)	1.1				0.5			

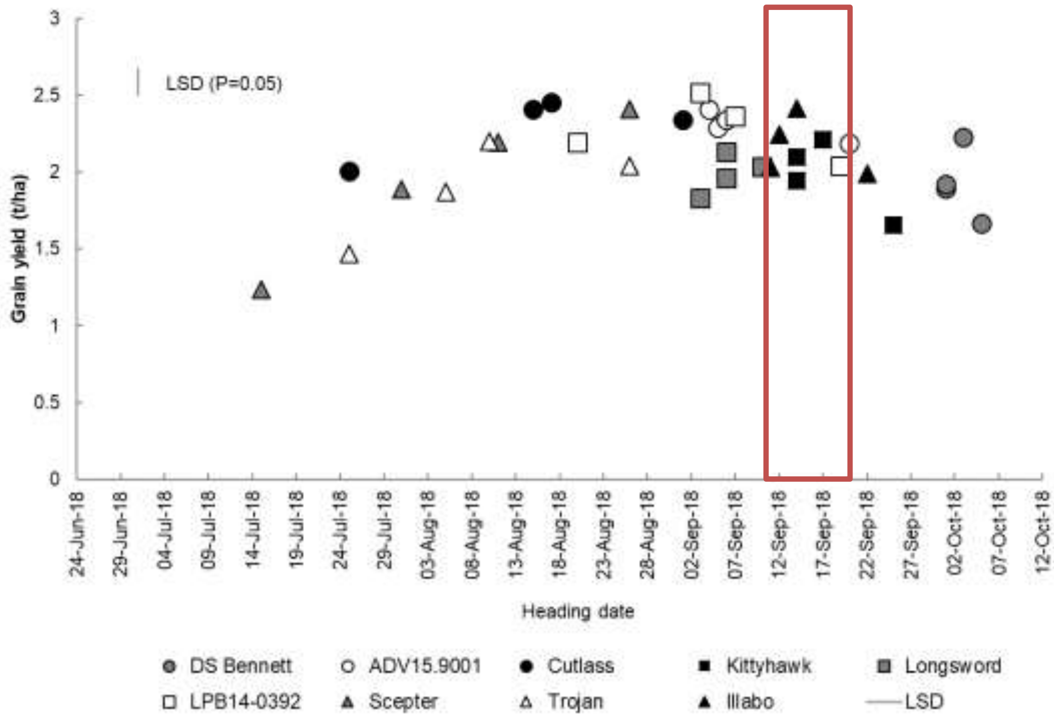

Figure 1. Average yield and heading date for all varieties and times of sowing. The red rectangle highlights the optimal flowering period for Hart.

Booleroo

Achieving good plant establishment has been a challenge at Booleroo, particularly from March sowing dates. All four times of sowing were irrigated to achieve germination. Due to the lack of rainfall and high soil temperatures during March and April, times of sowing one and two appeared dead on the surface by the end of May. However, below the soil surface the coleoptile (section above the seed) remained alive (Figure 2) in the majority of plants. In early June the site received 30 mm across 10 days and many plants regenerated along with a secondary germination. At the final establishment count the plants populations were 67, 84, 111 and 136 plants/m^2 across time of sowing one to four.

Figure 2. Plot of Scepter wheat sown 21st March (left) and plants removed from the plot (right) taken on 22nd May, 2018.

The regeneration of plants and death of the main stem had an interesting impact on phenology. For the spring varieties such as Scepter and Trojan it effectively pushed the 'reset button' due to the fact they were in the reproductive phase when severe moisture stress hit. This meant they restarted their lifecycle at the time of rain in early June. As a result across all times of sowing, Scepter flowered within 10 days of each other which was not expected (Figure 3). As observed in 2017, Scepter was the best performing variety within the trial at Booleroo ranging from 0.6 – 0.8 t/ha (Table 3). Both Trojan and Cutlass sown in early May performed similar to Scepter.

Overall the research project has shown the fastest developing winter wheat Longsword has been the most consistent performing winter wheat in low yielding (<2.5 t/ha) sites such as Booleroo, Minnipa and Loxton. In 2018 Longsword was also the best performing winter wheat and yielded similar to Scepter sown in its optimal window highlighting the need for faster developing winter wheats for environments similar to Booleroo.

Within the current suite of winter wheats there are few varieties well adapted to Booleroo's environment. Across all of the early sown wheat experiments in SA, Booleroo has been the most challenging for winter wheat production. In 2017, Booleroo was the only site where winter wheats did not perform similar to Scepter and yielded 0.7 t/ha less.

Test weight, screenings and protein were not determined due to insufficient grain sample size for processing.

Table 3. Grain yield and quality for all wheat varieties at different times of sowing at Booleroo in 2018. Treatments shaded in grey and not significantly different from the highest treatment.

Variety	March 21st	April 4th	April 18th	May 5th
	Grain yield (t/ha)			
Scepter	0.74	0.79	0.64	0.71
Trojan	0.51	0.71	0.62	0.76
Cutlass	0.51	0.66	0.60	0.70
LPB14-0392	0.19	0.24	0.36	0.23
Longsword	0.42	0.64	0.61	0.57
Illabo	0.37	0.23	0.38	0.28
Kittyhawk	0.35	0.37	0.30	0.30
DS Bennett	0.28	0.27	0.15	0.23
ADV08.0008	0.24	0.30	0.29	0.28
LSD(P≤0.05)	0.15			

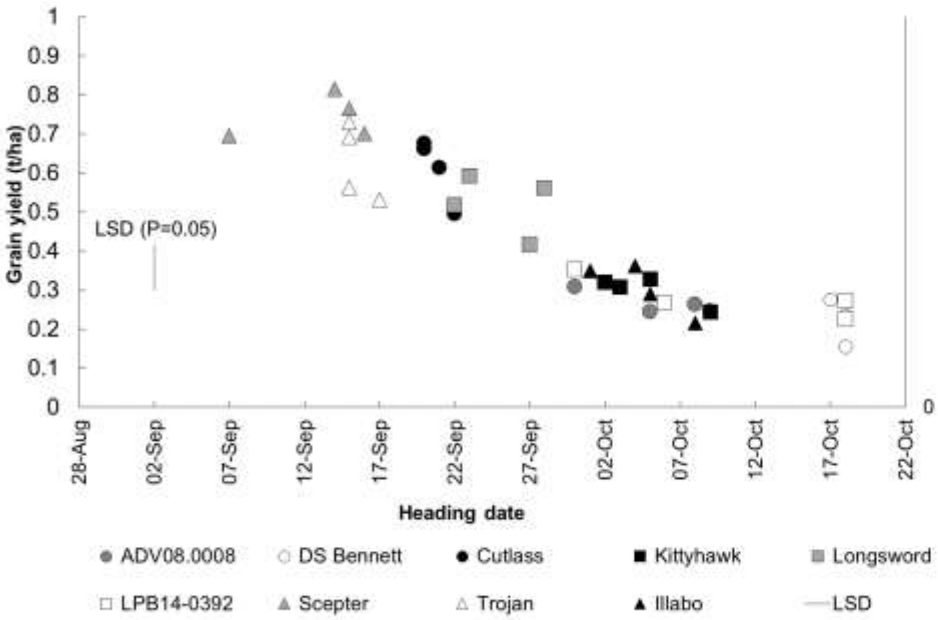

Figure 3. Average yield and heading date for all varieties and times of sowing at Booleroo Centre in 2018.

Summary

Across the entire project (eights sites in SA and VIC) the best performing winter wheat varieties depended upon yield environment, development speed and the severity and timing of frost / heat stress. In over 20 experiments the best performing winter wheat at each site was able to achieve yields similar to Scepter sown in its optimal window. The only exception to this was at Booleroo in 2017 where Scepter outperformed the winter wheats.

In environments greater than 2.5 t/ha, mid-slow developing wheat varieties were favoured for example Illabo at Hart. In environments less than 2.5 t/ha such as Booleroo the faster developing Longsword is favoured. However, the results for Booleroo have not consistently shown that winter wheats are suitable for this environment.

Acknowledgements

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Drivers of flowering time in durum

Melissa McCallum, Courtney Peirce & Kenton Porker, SARDI Waite

Key findings

- There is limited variation in flowering times of Australian durum varieties.
- The main driver of flowering time in durum is photoperiod – this means there are currently no durum varieties suited to pre-ANZAC day sowing, as they flower too early.
- Even the best performing durum varieties were unable to out yield Scepter in any environment, despite similar flowering times.
- Durum wheats have a greater susceptibility to frost and crown rot than bread wheats.

Why do the trial?

Flowering time is a crucial factor in determining yield and yield stability across seasons. To maximise yield it is essential to achieve flowering within the optimal period by sowing at the correct time for a given variety. Understanding of the flowering controls and development type and speed of varieties is essential to managing flowering time. This information is readily available for bread wheats with the optimum flowering period well defined for many areas in SA but is not available for durum wheats. By increasing our understanding of what drives flowering time in durum, yield and yield stability can be improved.

How it was done?

Plot size	1.75 m x 5.0 m	**Seeding date**	<u>Giles Corner (Tarlee)</u>	<u>Loxton</u>
			ToS 1 – 17th April	ToS 1 – 3rd May
			ToS 2 – 22nd May	ToS 2 – 4th June

The trial was a split-plot design with three replicates of 12 varieties (Table 1) at two times of sowing at two sites. The first time of sowing at each site was irrigated with 10 mm to ensure even establishment. Fungicides and herbicides were applied as necessary to keep the crop canopy free of diseas and weeds. Flowering date, frost induced sterility and yield components were measured at maturity and grain yield taken for each plot.

Table 1. Varieties used in field trials at Loxton and Giles Corner.

Scepter*	DBA-Aurora	Saintly	Yallaroi
Trojan*	DBA Spes	Tamaroi	Yawa
Caparoi	DBA Vittaroi	Tjilkuri	UAD 1154197

**indicates bread wheat varieties*

The controls of flowering time for durum were characterised in a controlled environment cabinet in The Plant Accelerator at Waite. The durum and bread wheat varieties included in Table 1 were compared with a range of durum breeding lines for photoperiod (day length) and vernalisation (cold period) requirements. Each pot was monitored for growth stages including stem elongation and flowering.

A more intensive flowering time experiment was conducted in the bird-proof enclosure at Waite Campus. The same 12 varieties were grown in double row x 1 m plots at six times of sowing, once every two weeks from the 10th April to the 19th June. These plots were monitored for growth stages including stem elongation and flowering.

Results and Discussion

Flowering time in durum is primarily driven by temperature and changes in day length (photoperiod). Results from the flowering time trial (Figure 1) showed that as photoperiod increased and sowing was delayed from April through to June there was a decrease in thermal time (growing degree days °C from emergence) to flowering. The controlled environment experiment showed that a few durum varieties respond to a cold period (vernalisation) to trigger flowering, however the response is facultative (will respond to vernalisation but is not always required) not obligate (requires vernalisation) because all varieties were able to flower without a cold period (Figure 2).

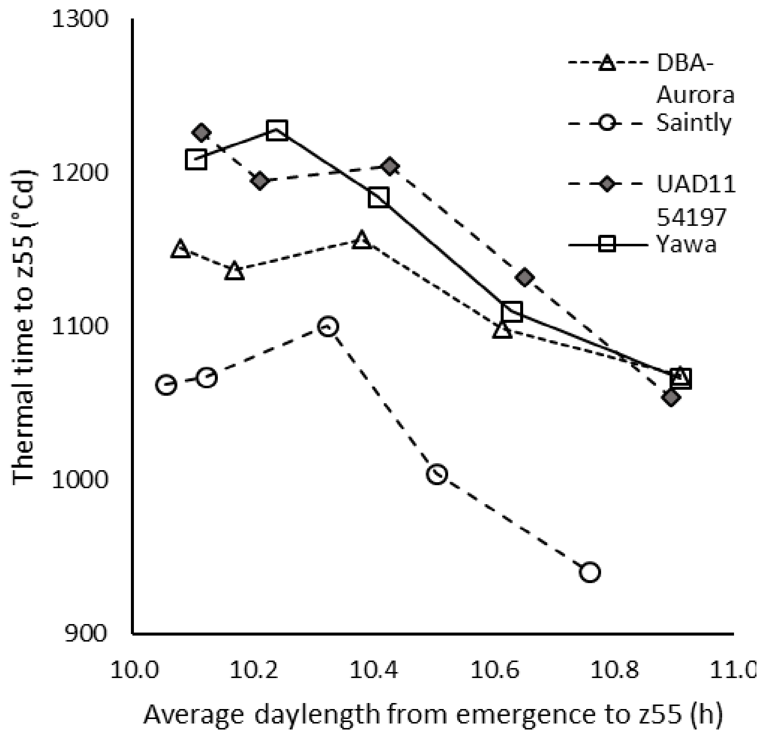

Figure 1. Average thermal time to heading (z55) against the average day length from emergence to heading for selected varieties at last five times (24 April – 19 June) of sowing in the bird-proof enclosure in 2018.

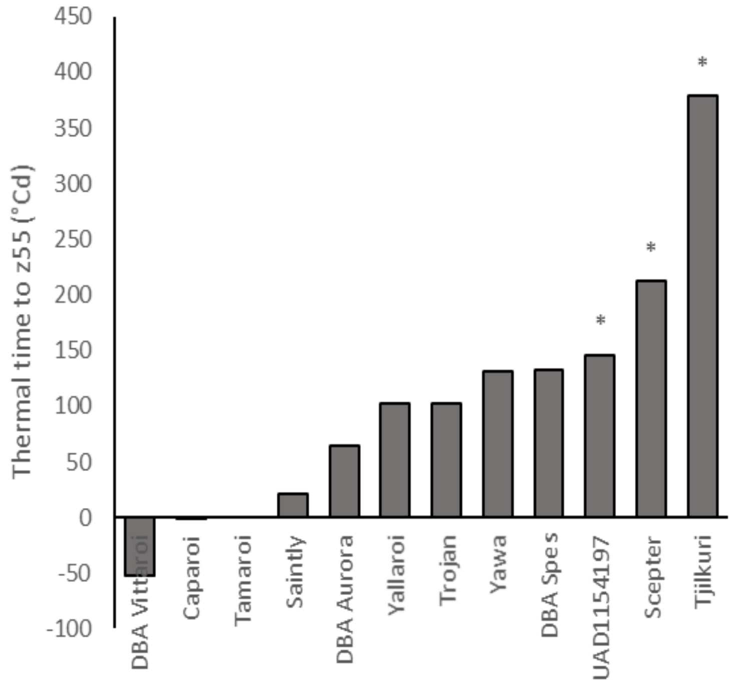

Figure 2. Vernalisation response of durum varieties and two bread wheats (Scepter and Trojan) grown at constant temperature of 22°C under an 18-h photoperiod. Vernalisation response calculated as difference in average growing degree days between non-vernalised and vernalised plants.
**Indicates the least significant difference between growing degree days of non-vernalised and vernalised plants (LSD. 133.2 °Cd; split-plot ANOVA, p≤0.05).*

Tjilkuri and UAD1154197 are responsive to vernalisation meaning a cold period will reduce the time to flowering but is not essential. From our field trials, Saintly and DBA Vittaroi appear to be the fastest developing durum varieties, while Tjilkuri, Yallaroi, and UAD1154197 are the slowest developing. From a late April sowing there was 15 days difference in flowering between DBA Vittaroi and UAD1154197. The lack of an obligate vernalisation and strong photoperiod requirements for flowering means that sowing durum varieties before ANZAC day is not suitable as they will flower too early.

At Giles Corner, the date of 50% heading for durums varied by four weeks (4 August - 1 September) at the first ToS but only nine days (19-28 September) for the second. Scepter out yielded all durum varieties (Table 2). Yawa at the second ToS was the highest yielding durum. Interestingly, Saintly and Scepter flowered within a day of each other at Giles Corner suggesting they have very similar flowering controls, but the yield gap was 0.9 t/ha and 1.5 t/ha for ToS 1 and 2 respectively (Table 2).

At Loxton for ToS 1, heading occurred over three weeks from the earliest variety DBA Vittaroi to the latest UAD1154197. While at ToS 2 heading varied by 16 days from Saintly and DBA Vittaroi to UAD1154197 (Table 3). At the second time of sowing no durum out yielded Scepter. Once again, Saintly and Scepter flowered within one day of each other but Scepter yielded significantly more, with a difference of 0.7 t/ha and 0.6 t/ha at ToS 1 and 2 respectively.

Table 2. Average yields (t/ha) and heading dates for the different varieties at Giles Corner.

	17th April			**22nd May**		
	Yield (t/ha)	% of Scepter average	Heading date	Yield (t/ha)	% of Scepter average	Heading date
DBA Vittaroi	3.0	70	4-Aug	3.2	67	19-Sep
Saintly	3.3	78	13-Aug	3.3	70	19-Sep
DBA Spes	3.0	72	16-Aug	3.2	67	21-Sep
DBA-Aurora	2.8	67	17-Aug	3.3	68	21-Sep
Trojan	4.5	105	21-Aug	4.4	92	21-Sep
Tamaroi	2.8	67	17-Aug	2.8	58	23-Sep
Caparoi	3.2	76	20-Aug	3.2	68	23-Sep
Yawa	3.4	81	29-Aug	4.0	84	23-Sep
Tjilkuri	3.3	78	23-Aug	2.6	53	25-Sep
Yallaroi	3.0	72	24-Aug	2.2	46	26-Sep
UAD1154197	3.0	71	1-Sep	2.7	57	28-Sep
Scepter	4.2	100	13-Aug	4.8	100	18-Sep
LSD (P≤0.05)	*0.4*			*0.7*		

Table 3. Average yields (t/ha) and heading dates for the different varieties at Loxton.

	3rd May			**4th June**		
	Yield (t/ha)	% of Scepter average	Heading date	Yield (t/ha)	% of Scepter average	Heading date
DBA Vittaroi	1.0	71	12-Aug	0.9	55	21-Sep
DBA-Aurora	1.1	74	16-Aug	0.9	56	23-Sep
Tamaroi	1.4	94	18-Aug	0.9	56	23-Sep
Saintly	0.7	52	19-Aug	1.0	62	11-Sep
Trojan	1.4	96	25-Aug	1.3	78	23-Sep
DBA Spes	1.4	96	26-Aug	1.0	62	20-Sep
Tjilkuri	0.7	50	27-Aug	0.8	49	25-Sep
Caparoi	1.1	77	29-Aug	0.9	58	16-Sep
Yallaroi	0.8	58	30-Aug	0.8	51	22-Sep
Yawa	1.3	90	1-Sep	0.7	46	27-Sep
UAD1154197	1.0	71	6-Sep	1.0	62	27-Sep
Scepter	1.4	100	20-Aug	1.6	100	10-Sep
LSD (P≤0.05)	*0.4*			*0.3*		

The yield gap between bread wheats and durum can be explained by the differences in susceptibility to crown rot and frost. Severe crown rot and moisture stress around head emergence and flowering can cause whiteheads and the complete abortion of any grain in the head. Frost can also affect yield, with temperatures below 2°C causing abortion of grain and flowers. At Giles Corner the primary cause of sterility was frost, while at Loxton both crown rot and frost caused sterility (Table 4). All current durum varieties are classified as very susceptible (VS or SVS) to crown rot unlike bread wheat varieties which have higher levels of resistance (Scepter S, Trojan MS) (Wallwork 2018). Durum varieties are also more sensitive to frost.

At Giles Corner, where frost was the major cause of sterility, Saintly and Scepter flowered on the same day at the first ToS but Saintly had double the sterility at 26% (Table 4) and yielded about 0.7 t/ha less (Table 3). There is variation in frost sensitivity of durums with varieties that flowered at similar times showing different levels of sterility i.e. Yawa and Tjilkuri (Table 4).

Table 4. Correlation between yield and sterility for each environment and the average sterility of selected varieties

	Environment							
	Giles Corner ToS 1 17th April		Giles Corner ToS 2 22nd May		Loxton ToS 1 3rd May		Loxton ToS 2 4th June	
Yield: Sterility	-0.53***		-0.66***		-0.45**		-0.35*	
	Sterility (%)	Heading date	Sterility (%)	Heading date	Sterility (%)	Heading date	Sterility (%)	Heading date
Scepter	13%	13 Aug	12%	18 Sep	5%	20 Aug	12%	10 Sep
Saintly	26%	13 Aug	24%	19 Sep	46%	19 Aug	30%	11 Sep
Tjilkuri	50%	23 Aug	43%	25 Sep	19%	27 Aug	26%	25 Sep
Yawa	32%	29 Aug	16%	23 Sep	8%	1 Sep	5%	27 Sep

indicates correlations that were significant at *(P≤0.05), **(P≤0.01), and *(P≤0.001).*

Summary / implications

Flowering time in durum is primarily controlled by changes in photoperiod with a few varieties having a facultative (not always required) response to vernalisation, however the variation in flowering time of durum varieties is very limited compared to that of bread wheats. Currently, there are no durum varieties suited to pre-ANZAC day sowing as they will all flower too early and be exposed to cold stresses. The current variation in durum dictates that sowing is best suited to early to mid-May. Durum wheat may be better suited to later flowering to avoid frost risk, as they are much more sensitive than bread wheats. The lack of variation in development speed for durum means variety selection should focus on other variety qualities, including yield potential and quality characteristics rather than development speed.

Acknowledgements

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Legume and oilseed herbicide tolerance

Key findings

- In the post emergent treatments a range of herbicides produced very good control of all oilseed and legume crops included.

Why do the trial?

To compare the tolerance of legume and canola varieties to a range of herbicides and timings.

How was it done?

Plot size	2.0 m x 3.0 m	**Fertiliser**	MAP (10:22) + 2% Zn @ 75 kg/ha
Seeding date	1st June 2018		

Thirteen strips of canola, pasture, vetch, chickpea, faba bean, field pea and lentils were sown. Forty herbicide treatments were applied across all 13 crops at different timings.

The timings were:

Post seeding pre-emergent (PSPE)	4th June
Early post emergent (3-4 node)	27th July
Post emergent (5-6 node)	20th August
Late post emergent (8 node)	7th September

Treatments were visually assessed and scored for herbicide effects approximately four weeks after application (Table 1).

Crop damage ratings were:

1 = no effect
2 = slight effect
3 = moderate effect
4 = increasing effect
5 = severe effect
6 = death

Results

Many of the herbicides used here are not registered for the crops that have been sprayed. It is important to check the herbicide label before following strategies used in this demonstration. In 2018 a number of the herbicide treatments produced different crop tolerance or control ratings than expected. Care should be taken when interpreting these results as herbicide effects can vary between seasons and depend on soil and weather conditions at time of application.

The majority of post sowing pre-emergent (PSPE) herbicide applications had no effect on legume crop growth compared to the nil (Table 1), while all the canola varieties were significantly effected. This would not usually be expected and can be attributed to the dry surface soil conditions during the months of June and July following application.

At the 3 – 4 node application simazine was the safest herbicide option and has been across a number of seasons. At this timing, metribuzin was more damaging to both lentil varieties (rating >5), vetch and Genesis090 chickpea. This season, Broadstrike caused severe effects in RM4 vetch and noticeable damage in Zulu II clover.

Ecopar is now registered in pastures, vetch, field pea and faba bean however, its use in other crops remains off label. Refer to the crop safety on label for specific variety information. In the Hart trial at the 3-4 node application, Ecopar resulted in slight damage (1 - 2 rating) to most of the legumes, but moderate damage (3 rating) in both lentil varieties.

In the post emergent 5 - 6 node treatments a range of herbicides produced very good control of all the oilseed and legume crops. These included Eclipse, Vortex, Paradigm, Velocity, Triathlon and Starane. Ecopar was safe on field peas in the last three seasons. It should also be noted that crop establishment in the pasture section (Zulu II and Sultan SU) was patchy and poor early vigour contributed to a number of herbicides causing significant damage scores compared to those usually observed. Linseed was a new addition to the trial and was not controlled by a number of the 5-6 node treatments this season.

For some of the newer product entries in the 5-6 node section:

- Pixxaro with Arylex active (16.25 g/L Arylex + 250 g/L fluroxypyr) is a post-emergent herbicide for use in all winter cereals from 3 leaf to flag leaf for the control of a range of broadleaf weeds. Pixxaro has resulted in good control of the legume crops in this trial over the past three years.
- Rexade is a post emergent grass plus broadleaf herbicide for use in wheat. It contains the group B herbicide pyroxsulam plus the new Group I herbicide Arylex (halauxifen-methyl). It can be tank mixed with a range of broadleaf herbicides, typically MCPA LVE. In 2017 and 2018 Rexade gave very good control of the legume and canola crops.
- Talinor (37.5 g/L bicyclopyrone and 175 g/L bromoxynil) is a new fast acting cereal broadleaf herbicide that offers broad spectrum post-emergent weed control in wheat and barley (excluding durum). This product has been in the Hart herbicide matrix for three seasons and provided excellent control of all the legume and oilseed crop types.

In the 8 - 9 node treatments Gunyah peas and Genesis090 tolerated MCPA amine, and a low rate of 2,4-D ester. Thistrol Gold (NUL3342) was a new entry (likely registration 2020) and will be registered for clover and grass pastures. The label will feature a broad spectrum of weeds, including various thistles and brassica type weeds. This product showed good safety on Zulu II clover at Hart this year.

Table 1. Crop damage ratings for legume and oilseed herbicide tolerance trial at Hart 2018.

Number	Application Timing	Treatment	Rate kg/ha	Pasture	Pasture	Lentil	Lentil	Vetch	Vetch		C/pea	Pea	Bean	Canola	Canola	Canola
				Zulu II	Sultan SU	Hurricane	Jumbo 2	Timok	RM 4	Linseed	Genesis090	Gunyah	Nura	Pioneer 44Y90	Hyola®559TT	Nuseed Quartz
				8	10	55	45	45	45	40	120	100	140	4	4	4
1	Post sow pre-emergent 4th June 2018	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1
2		Diuron (900 g/kg)	825 g	6	1	1	1	1	1	2	1	1	1	5	5	6
3		Simazine (900 g/kg)	825 g	6	4	1	1	2	1	4	1	1	2	4	3	5
4		Metribuzin (750 g/kg)	280g	6	1	3	3	3	3	6	1	1	1	5	3	5
5		Terbyne (750 g/kg)	1000 g	6	6	1	1	2	2	6	1	1	1	6	3	6
6		Balance + Simazine	100 g + 830 g	6	6	6	6	6	6	6	3	6	6	6	6	6
7	3-4 Node 27th July 2018	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1
8		Simazine (900 g/kg)	850 g	5	1	2	2	1	1	1	2	1	3	3	3	3
9		Metribuzin (750 g/kg)	280 g	6	5	5	6	6	6	6	3	1	3	6	3	5
10		Broadstrike + Wetter 1000	25 g + 0.2%	3	1	2	2	2	6	4	2	2	4	2	4	4
11		Brodal Options	150 mL	5	4	2	3	4	5	2	5	2	4	4	4	5
12		Brodal Options + MCPA Amine 750	150 mL + 100 mL	4	3	4	4	3	4	2	4	2	4	5	5	4
13		Spinnaker + Wetter 1000	70 g + 0.2%	4	1	2	4	3	4	3	4	2	4	3	6	6
14		Raptor + Wetter 1000	45 g + 0.2%	3	1	1	4	3	2	1	4	1	2	2	6	6
15		Ecopar + Wetter 1000	800 mL + 0.2%	2	1	3	3	1	1	5	2	2	2	1	3	4
16	5 - 6 node 20th Aug 2018	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1
17		Ally + Wetter 1000	7 g + 0.1%	6	5	5	6	4	6	1	6	6	6	4	6	6
18		Eclipse SC + Wetter 1000	50 mL + 0.1%	6	4	4	6	6	5	4	5	5	6	4	6	6
19		Atrazine + Hasten	1000 g + 1%	6	4	4	4	3	3	1	4	4	4	4	1	5
20		Lontrel 600	150 mL	6	6	6	6	6	6	2	4	4	6	1	1	1
21		Ecopar + MCPA Amine 750	400 mL + 330 mL	4	4	4	4	4	4	2	3	3	4	5	5	5
22		Jaguar	1000 mL	4	4	4	5	5	3	2	4	4	3	6	6	5
23		Carfentrazone + MCPA Amine 750	100 mL + 330 mL	4	3	4	4	4	4	2	4	4	4	6	6	6
24		Velocity + Uptake	670 mL + 0.5%	6	6	6	6	6	6	2	6	6	6	6	6	6
25		Talinor + Hasten	750 mL + 1 %	6	6	6	6	6	5	2	6	6	6	6	6	5
26		Paradigm + MCPA LVE + Uptake	25 g + 500 mL + 0.5%	6	6	6	6	6	6	6	6	6	6	6	6	6
27		Vortex + Uptake	820 mL + 0.5%	6	3	6	6	5	6	4	6	6	6	6	6	6
28		Flight EC	720 mL	3	3	5	5	3	3	2	3	3	5	6	6	6
29		Triathlon	1000 mL	3	4	5	6	5	5	3	5	4	5	6	6	6
30		Intervix + Hasten	600 mL + 0.5%	5	2	1	4	5	4	4	3	3	4	1	6	6
31		Starane	600 mL	3	4	6	6	6	6	6	6	6	4	4	4	4
32		Pixxaro + Uptake	300 mL + 0.5%	6	6	6	6	6	6	6	6	6	6	3	3	3
33		Rexade + Wetter 1000	100 g + 0.25%	6	5	5	6	6	6	6	5	5	6	1	6	6
34		Atlantis OD + Hasten	330 mL + 0.5%	6	4	4	5	6	6	2	6	6	6	1	6	6
35	Late post emergent 8 - 9 node 7th Sep 2018	**NIL**		1	1	1	1	1	1	1	1	1	1	1	1	1
36		MCPA Amine (750 g/L)	350 mL	2	1	4	2	4	5	2	2	2	4	2	2	2
37		2,4-DB 500 g/L	1500 mL	3	1	2	2	2	3	2	2	2	4	2	2	2
38		Thistrol Gold + NUL3279	2000 mL + 0.5%	2	2	4	4	4	5	4	3	3	5	5	5	5
39		Amicide Advance 700	1200 mL	5	5	6	5	5	6	4	5	5	6	5	4	4
40		2,4-D Ester (680 g/L)	70 mL	2	2	2	2	3	2	2	3	3	3	2	1	1

Weed suppression with canola and pre-emergent herbicides

Chris Preston, University of Adelaide and Sarah Noack, Hart Field-Site Group

Key findings

- In 2017 and 2018, both open pollinated (ATR-Bonito) and hybrid (Hyola559TT and HyTTec Trophy) varieties provided similar crop competition for ryegrass control.
- This season, below average rainfall reduced the efficacy of the pre-emergent herbicides that require rainfall for activation.
- There was no significant effect of herbicide treatment or variety on canola grain yield.

Why do the trial?

The extent of resistance to clethodim in annual ryegrass is increasing, as is the level of resistance in these populations. This requires new tactics for management of annual ryegrass in canola. Pre-emergent herbicides are increasing in importance and new pre-emergent herbicides are now available including Butisan (metazachlor) and Devrinol (napropamide). However, pre-emergent herbicides on their own tend not to control annual ryegrass seed production. Using more competitive canola varieties is one tactic that can be added to pre-emergent herbicides to improve annual ryegrass control.

The trial aimed to evaluate the combination of competition from canola varieties and pre-emergent herbicides on suppression of annual ryegrass.

How was it done?

Plot size	2.0 m x 10.0 m	**Fertiliser**	DAP (18:20) + 2% Zn @ 100 kg/ha
Seeding date	15th May 2018		UAN (42:0) @ 95 L/ha on 5th July UAN (42:0) @ 55 L/ha on 2nd Aug

Two canola varieties, ATR Bonito, an open pollinated variety, and HyTTec Trophy, a hybrid, were sown. Herbicides applied IBS were applied immediately prior to sowing with POST atrazine applied on the 25th of June. Herbicides used on both canola varieties are listed in Table 1.

The trial was established as a randomised complete block design (RCBD) with three replicates. Assessments included ryegrass plant density on 5th July and seed heads on 24th October, and canola grain yield (harvested on 8th November).

Table 1. Herbicide treatments used at Hart in 2018.

Herbicide treatment	Products	Rates
1	Nil	-
2	Propyzamide (900 g/kg) IBS	550 g/ha
3	Butisan IBS	1.8 L/ha
4	Devrinol IBS	2 kg/ha
5	Atrazine IBS + Atrazine POST	1.1 kg/ha + 1.1 kg/ha
6	Propyzamide (900 g/kg) IBS + Atrazine POST	550 g/ha + 1.1 kg/ha
7	Butisan IBS + Atrazine POST	1.8 L/ha + 1.1 kg/ha
8	Devrinol IBS + Atrazine POST	2 kg/ha + 1.1 kg/ha

Results and discussion

Annual ryegrass populations were relatively low in the trial with an average of 49 plants/m^2 in the nil herbicide treatments (Table 2). The herbicide treatments all significantly reduced annual ryegrass populations compared to the untreated control. There was no effect of variety on annual ryegrass plant density in the trial (Figure 1).

The dry seasonal conditions during 2018 would have reduced the efficacy of the pre-emergent herbicides that require rainfall for activation. Therefore, the more water-soluble products, such as Butisan, often perform better under such circumstances. On the other hand, dry conditions reduce later emerging weeds and extended persistence of pre-emergent herbicides is less useful.

Figure 1. Similar plant vigour in canola varieties HyTTec Trophy and ATR Bonito (nil herbicide applied) at Hart. Image taken on 23rd August, 2018.

For annual ryegrass seed production, measured as heads/m^2, there was a significant effect of herbicide treatment, but not of variety (Table 2). The low growing season rainfall in 2018 did not allow the HyTTec Trophy to perform as well as it might. Greenseeker NDVI results (data not shown) were similar for both varieties on the 9th of July; HyTTec Trophy 0.36 versus ATR Bonito 0.31. This lack of difference was carried through on the 10th August where HyTTec Trophy 0.65 compared to ATR Bonito 0.61.

Typically, hybrid varieties can reduce annual ryegrass seed set by up to 50% compared with open pollinated varieties; however, this difference is lower where more competitive open pollinated varieties, such as ATR Bonito, are sown. This is consistent with previous research at Hart and Roseworthy (2017), where ATR Bonito provided good early vigour and was equally competitive when compared with Hyola 559TT (hybrid). However, in 2016, Hyola 559TT reduced seed production 50% more than the open pollinated ATR Stingray (early maturing, short height). These studies highlight the variation among TT varieties in their competitive ability with weeds.

Table 2. Annual ryegrass plant and head numbers measured at Hart in 2018.

Herbicide treatment	ATR Bonito	HyTTec Trophy	Average	ATR Bonito	HyTTec Trophy	Average
	ARG July (plants/m^2)			Seed heads October (heads/m^2)		
1	53	44	49	93	72	83
2	16	13	15	24	15	20
3	17	6	12	38	23	30
4	14	11	13	43	28	35
5	24	21	22	18	25	22
6	11	14	13	23	24	24
7	17	14	16	23	32	27
8	22	22	22	45	40	43
Average	22	18		38	32	
Interaction	ns			ns		
Herbicide treatment	P < 0.0001			P = 0.005		
Variety	ns			ns		

Due to dry conditions canola yields were low, averaging 0.6 t/ha across the trial (Table 3). The combination of low weed populations and low growing season rainfall meant that there was no significant effect of herbicide treatment or variety on canola grain yield. Our past trials have indicated that there is often no yield advantage from growing hybrid canola where yields are below 1.5 t/ha, however, there is often a weed control advantage. That weed control advantage is less where there are low weed populations.

Table 3. Yield of ATR Bonito and HyTTec Trophy canola at Hart in 2018.

Herbicide treatment	ATR Bonito	HyTTec Trophy	Average
		Yield (t/ha)	
1	0.37	0.48	0.43
2	0.51	0.61	0.56
3	0.56	0.64	0.60
4	0.56	0.63	0.59
5	0.56	0.69	0.62
6	0.67	0.66	0.66
7	0.59	0.68	0.63
8	0.56	0.67	0.61
Average	0.55	0.63	
Interaction	ns		
Herbicide treatment	ns		
Variety	ns		

Acknowledgements

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Integration of crop competition and herbicide strategies for the management of annual ryegrass in canola

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Sarah Noack, Hart Field-Site Group

Key findings

- Atrazine pre-sowing followed by clethodim post-emergence reduced ryegrass plant density relative to the untreated control by 57%. The use of propyzamide pre-sowing, followed by atrazine and clethodim + Factor increased ryegrass control to 77%.
- Canola variety had a significant effect on ryegrass head density. When averaged across the sowing dates and herbicide strategies, ryegrass growing in HyTTec Trophy produced 52 heads/m^2 as compared to 78 heads/m^2 in ATR Bonito.
- Herbicide treatment application produced canola yields of around 0.8 t/ha, which was almost 50% greater than the yield obtained in the control. These results highlight the competitive ability of ryegrass against canola, especially in a dry 2018 season.

Why do the trial?

Farmers in the southern region have been gradually moving towards earlier sowing times for canola. In fact, many growers have been seeding canola into dry soil in mid-late April. Canola crops sown early tend to respond positively to the warm growing conditions and crop canopy closure can be rapid in such situations. Therefore, early sowing could be highly beneficial in achieving greater suppression of weeds such as ryegrass. Previous research has shown there can be differences in early vigour between hybrids and open pollinated TT varieties, which could play an important role in weed suppression. Therefore, it is important to investigate the combinations of sowing time x variety to identify best-bet cultural weed management tactics for canola.

The cost of hybrid canola seed is high (> $30 /kg) and many growers reduce their seeding rate to reduce production costs. Under weedy conditions, there may be a significant penalty for reducing plant density of hybrid varieties but this has not been tested experimentally. In Western Australia, French et al. (2016) showed that canola plant densities < 20 plants/m^2 were more vulnerable to ryegrass competition especially open-pollinated triazine tolerant varieties.

The aim of this trial is to investigate factorial combinations of sowing time, varieties and seed rate with herbicide strategies for ryegrass management.

How was it done?

Location	Washpool (near Spalding) *(rainfall refer to page 13)*		
Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + Zn 2% @ 80 kg/ha Urea (46:0) @ 100 kg/ha in-season
Seeding date	16th May, 2018 31st May, 2018		
Varieties	Bonito (OP) HyTTec Trophy (hybrid) TT		
Seeding rates	25 plants/m^2 38 plants/m^2 50 plants/m^2		
Herbicides	HS1 - Atrazine 2.2 kg/ha IBS + clethodim 500 mL/ha at GS14 of ARG HS2 - Propyzamide 1 L/ha IBS + atrazine 1.1 kg/ha at GS12 of ARG + Clethodim 0.5 L/ha + Factor 80 g/ha at GS14 of ARG HS3 - Control (knockdown treatment only)		

Results and discussion

Canola plant density

Canola plant density was significantly influenced by seeding rate. Averaged across the two sowing dates, herbicide treatments and the two varieties, canola plant density increased from 32 plants/m^2 in the low seed rate to 44 plants/m^2 in the medium seed rate to 63 plants/m^2 in the high seed rate (Figure 1). Even though canola plant density in HyTTec Trophy was greater than Bonito by 10-20%, the differences between the two varieties were non-significant.

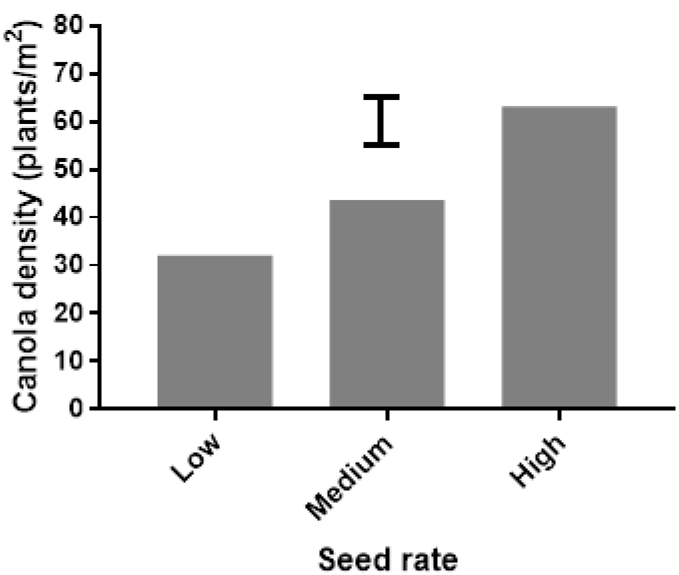

Figure 1. The effect of canola seed rate on its plant density. The vertical bar represents LSD (P=0.05).

Ryegrass plant and head density

The experimental site had a moderate infestation of annual ryegrass. In the control (nil herbicide) plots, ryegrass plant density was 88 plants/m^2 in sowing time one and 100 plants/m^2 in sowing time two. This result indicates that the two-week delay in sowing had no impact on annual ryegrass plant density. The herbicide strategy was the only factor to have a significant effect on ryegrass density. HS1 reduced ryegrass plant density relative to the control (nil herbicide) by 57% as compared to 77% reduction in HS2 (Figure 2 and Photo 1). However, the differences between these two herbicide strategies were non-significant.

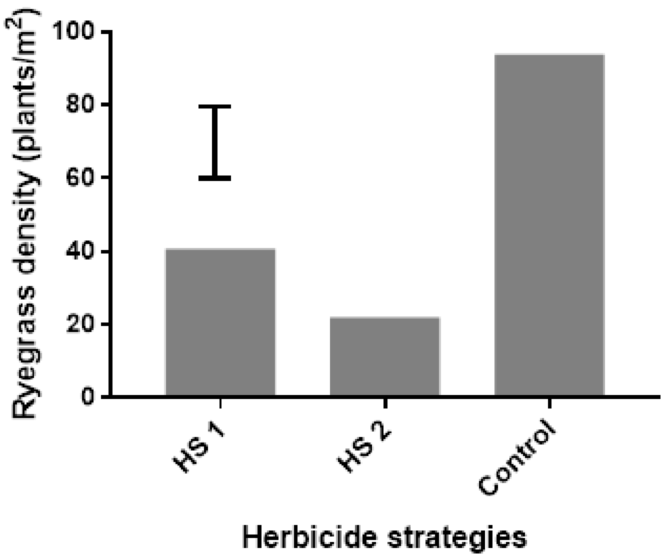

Figure 2. The effect of herbicide strategies on ryegrass plant density. The vertical bar represents LSD (P=0.05).

Data on ryegrass head density revealed greater differences between the management factors investigated. Canola variety had an effect on ryegrass head density. When averaged across the sowing dates and herbicide strategies, ryegrass growing in HyTTec Trophy produced 52 heads/m^2 as compared to 78 heads/m^2 in Bonito (33% reduction). HyTTec Trophy is a new hybrid triazine tolerant variety from Nuseed, which is known for high early vigour. In contrast, Bonito is an open pollinated canola variety from Nuseed. It is possible these differences in early vigour may have contributed to the significant differences in ryegrass head density between HyTTec Trophy and Bonito. However, in a similar trial at Hart in 2018, we were unable to detect differences in ryegrass control in these two canola varieties. The lack of differences at Hart, could be attributed to seasonal effects (reduced early vigour in general) and a lower ryegrass population.

Herbicide strategies also had a significant effect on ryegrass head density. Ryegrass grown without any selective herbicide treatment (control) produced 128 heads/m^2 as compared to 40 heads/m^2 in HS1 and 29 heads/m^2 in HS2. This works out to 69% reduction in HS1 relative to the control and 78% reduction in HS2.

There was a significant interaction between the time of sowing and the herbicide strategies. This interaction appears to be associated with greater ryegrass head density in time of sowing two, which may be an indication of reduced competitive ability of canola when sown later. However, herbicide activity against ryegrass was greater in time of sowing two which may be associated with wetter soil conditions leading to better herbicide uptake and activity (Figure 3). For example, HS2 only had 8 ryegrass heads/m^2 in the later time of sowing as compared to 50 heads/m^2 in time of sowing one.

Photo 1. Annual ryegrass in Bonito and HyTTec Trophy (medium seeding rate) under three herbicide strategies. Photos taken 11th Sept, 2018.

There was also an interaction between time of sowing, variety and herbicide, which was associated with superior weed competitive ability of HyTTec Trophy in time of sowing two. Ryegrass head density in Bonito increased from 100 heads/m^2 in time of sowing one to 193 heads/m^2 in time of sowing two. This highlights poorer competitive ability in later sown conditions. In contrast, ryegrass head density in HyTTec Trophy was similar in across both times of sowing (103 heads/m^2 and 114 heads/m^2).

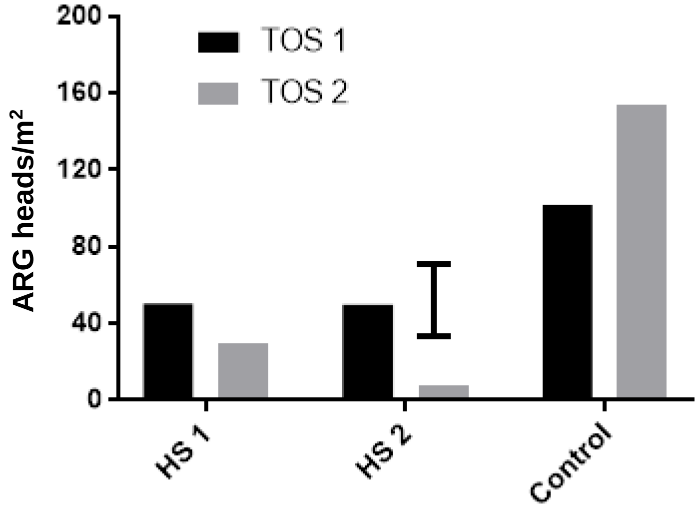

Figure 3. The interaction between sowing time and herbicide strategies (P<0.001) for ARG head density. The vertical bar represents LSD (P=0.05).

Annual ryegrass seed production

As was the case for ryegrass plant density, delayed sowing had no effect on ryegrass seed production. However, there were significant differences between the two canola varieties in ryegrass seed production. Averaged across the two sowing dates and herbicide treatments, ryegrass produced 3,775 seeds/m^2 in Bonito compared to 2,564 seeds/m^2 in HyTTec Trophy, a reduction of 32%. These results clearly highlight the potential for integrating vigorous hybrid varieties of canola for improving weed management.

Ryegrass seed production reflected the trends observed in head density data. There was a significant interaction between the time of sowing and herbicide strategies. Even though ryegrass seed set in the control was lower at the earlier time of sowing, when herbicide treatments were applied, ryegrass seed set was lower in time of sowing two (Figure 4). Greater herbicide activity in time of sowing two is likely to be due to better soil moisture at seeding time.

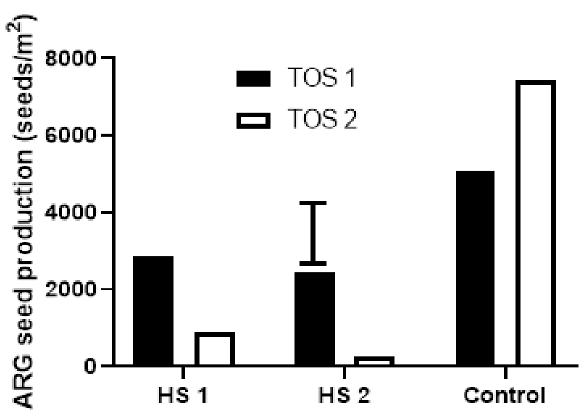

Figure 4. The effect of interaction between the time of sowing and herbicide treatments for ARG seed production. The vertical bar represents the LSD (P=0.05).

Canola grain yield

As expected, canola grain yield was reduced by the two-week delay in sowing dates. Averaged across the sowing dates, seed rates and herbicide treatments, HyTTec Trophy produced 40% greater grain yield than Bonito (0.50 t/ha Vs 0.83 t/ha). Canola seed rate also increased the grain yield; yield increased by 14% as plant density increased from 32 to 44 plants/m^2 and by 19% as density increased to 63 plants/m^2.

Herbicide strategies had the largest effect on canola yield. HS1 and 2 produced canola yield of around 0.8 t/ha, which was almost 50% greater than the yield obtained in the control (Table 1). These results highlight the competitive ability of ryegrass against canola, especially in a dry season such as 2018.

Table 1. The effect of three herbicide strategies on canola grain yield, averaged for both varieties.

Herbicide strategy	Canola grain yield (t/ha)
HS1 - Atrazine 2.2 kg/ha IBS + clethodim 500 mL/ha at GS14 of ryegrass	0.85
HS2 - Propyzamide 1 L/ha IBS + atrazine 1.1 kg/ha at GS12 of ryegrass + clethodim 0.5 L/ha + Factor 80 g/ha at GS14 of ryegrass	0.76
HS3 - Untreated control	0.39
LSD (P=0.05)	0.08

Gross margin analysis for the two varieties was undertaken based on grain yields averaged across the sowing dates, seed rates and herbicide treatments (Table 2). Based on the yield advantage of HyTTec Trophy over Bonito and taking into extra costs related to seed purchase and end point royalty, the gross margin for Trophy ($381) was $115/ha greater than for Bonito ($267). As oil content of canola grain was not determined, it is assumed that both varieties had a similar oil percentage.

Table 2. Estimation of gross margin for Bonito farmer retained seed and HyTTec Trophy. Canola yields for the two varieties are averages for the two sowing times, seed rates and herbicide treatments. Fertiliser and other management costs have been assumed to be identical for the two varieties.

Income	Bonito Farmer retained	HyTTec Trophy
Grain yield t/ha	0.50	0.83
Cash price $/t	550	550
Gross $/ha	276	457
Costs		
Seed cost per kg	2	19
Sowing rate kg/ha	3.7	3.5
Seed cost $	7	67
End point royalty $/t	5	10
EPR $/ha	2.5	8.3
Costs per ha	10	76
Gross margin $/ha	**267**	**381**

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Weed responses to high intensity break crop rotations

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Key findings

- Controlling Group A and B herbicide resistant annual ryegrass and Group B resistant common sowthistle in break crops is becoming increasingly challenging.
- Resistance in ryegrass to pre-emergence herbicides such as Boxer Gold® and Sakura® has been confirmed in high break crop intensity systems.
- Paddock survey results showed common sowthistle from paddocks with high IMI-use history had high incidence of IMI resistance. However, IMI resistance levels in paddocks where only sulfonylureas had been used, raises concern for resistance development to IMIs in other broadleaf weeds.
- The Group B tolerant faba bean PBA Bendoc⊕ provides a new opportunity for managing broadleaf weeds.
- Crop competition has the potential to reduce seed set of broad leaf weeds in some break crops.

Why do the research?

A number of improved herbicide tolerant break crop options are available such as triazine tolerant (TT) canola, imidazolinone (IMI) tolerant (Clearfield) canola and lentils e.g. PBA Hurricane XT. Their relatively high market prices, improved agronomic and disease characteristics and harvest efficiency have resulted in an expansion of the area sown to pulses and canola in South Australia. Growers using break crops can use a more diverse range of herbicide chemistry compared with that used in the cereal phase, particularly for grass weeds. This uptake has largely occurred in the Mid-North (MN), Yorke Peninsula (YP) and Lower Eyre Peninsula (LEP), where the total area under break crops is higher than the national average (Figure 1).

Ryegrass control in break crops relied heavily on Group A chemistry (fops and dims). This has contributed to increased herbicide resistance, in particular to the dim chemistry, making ryegrass control challenging. Consequently, herbicides with different modes-of-action (Groups D, J and K) have been adopted to manage dim-resistant ryegrass in high break crop intensity (HBCI) rotations. Careful management of Group D, J and K herbicides is required to minimise selection for resistance to any single mode of action. The introduction of TT canola, IMI tolerant canola and lentil have also improved broadleaf weed control options with triazine and IMI herbicides. However, they have resulted in a decreased frequency of other weed control tactics in these break crops. Over-reliance on triazines and IMI herbicides in herbicide tolerant break crops for improved broadleaf weed management could result in shifts in the weed spectrum and increase the incidence of herbicide resistance. This has occurred in Canada with the evolution of sulfonylurea (SU) and IMI resistant wild mustard (Warwick et al, 2005) as a result of high intensity use of ALS inhibiting herbicides. Resistance in broadleaf weeds presents a big challenge for IMI tolerant lentils.

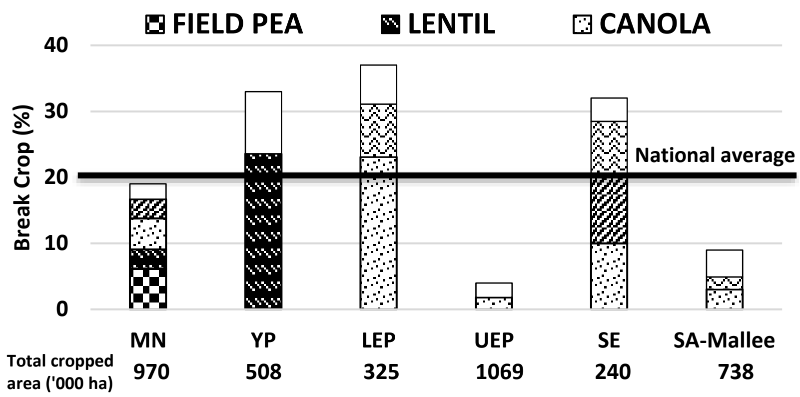

Figure 1. Distribution of break crops across different regions of South Australia. Source: PIRSA crop estimates 2017

A more sustainable approach is to include herbicide tolerant break crops as part of an overall weed management strategy, rather than focussing on short-term weed control in individual crops and seasons. Introducing strategies such as crop-topping to reduce seed set can significantly reduce weed seed banks (Preston, 2014). The adoption of effective diverse strategies will therefore aid in reducing the risk of resistance developing in high break crop intensity rotations.

Paddock survey

A paddock survey was initiated in 2017 to understand changes in weed and herbicide resistance, in response to low or high use of IMI herbicides in high intensity break crop rotations (at least two break crops in the last 5-6 years) across different regions of South Australia. A total of 45 focus paddocks were selected [MN-16, YP-11, LEP-8, Upper Eyre Peninsula (UEP)-2, South East (SE)-4, SA Mallee-4]. The selected paddocks had IMI tolerant break crops such as PBA Hurricane XT lentil (at least twice in the last five years) or Clearfield canola (twice in the last five to six years) sown as a dominant break crop. In addition to these, paddocks with two non-IMI break crops (conventional lentil, conventional canola/TT canola, field pea, chickpea, faba bean, lupin) were included. Seeds from ryegrass and two dominant broadleaf weed species were collected from these paddocks prior to harvest in 2017. They were screened for resistance in outdoor pot trials by Plant Science Consulting (Tables 1 and 2).

Ryegrass and common sowthistle were the dominant weed species encountered in the focus paddocks (Tables 1 and 2). Ryegrass resistance to SU and Dens (Axial) was detected in almost all paddocks (Table 1). A high incidence of ryegrass resistance to IMI was observed in both high IMI-history paddocks (56% of samples) and no-IMI history paddocks (63% of samples). In addition, a total of 46% of ryegrass populations were found to be resistant, and 21% had started developing resistance to clethodim in high break crop intensity paddocks (Table 1). This has started to limit the effectiveness of break crops as rotational tools.

Resistance to the Group J and K herbicides Boxer Gold and Sakura, albeit at low levels, was confirmed in ryegrass and is a concern (Table 1). One quarter of the ryegrass populations exhibited resistance to Boxer Gold (≥20% survivors). Half of the ryegrass biotypes resistant to Boxer Gold originated from high break crop intensity paddocks on Lower Eyre Peninsula where canola was the dominant break crop. Biotypes with ≥ 20% survival to Sakura® were not detected, although 1 to <20% survival in pot trials (developing resistance) was confirmed in one third of ryegrass populations, predominately from Lower Eyre Peninsula. The increase in resistance to pre-emergence herbicides highlights the need for careful and strategic use of these chemistries, particularly in the break crop phase. This might include rotational use of Group D herbicide propyzamide with Group J and K herbicides in the break crop phase.

Table 1. Herbicide resistance in annual ryegrass collected from high break crop intensity paddocks in SA. Resistance (where ≥ 20% survival was confirmed in pot tests) and developing resistance (where 1 to <20% survival was confirmed in pot tests) is presented below.

Resistant ryegrass populations									
Weed	**Samples tested**	**Trifluralin***	**Propyzamide**	**Boxer Gold**	**Sakura**	**Clethodim**	**Glean**	**Axial**	**Intervix**
Ryegrass	24	17 (71)	0	6 (25)	0	11 (46)	22 (92)	22 (92)	14 (58)
Ryegrass populations with developing resistance									
Ryegrass	24	3 (13)	0	4 (17)	8 (33)	5 (21)	1 (4)	1 (4)	2 (8)

** numbers (percent)*

Table 2. Percent resistant broadleaf weeds (≥ 20% survivors) observed in high break crop intensity paddocks of South Australia, samples taken in 2017.

Weed	**Ally**	**Intervix**	**Imazapic**	**2,4-D**	**Brodal**	**Bromoxynil**	**MCPA**	**Imazethapyr**	**Glean**	**Lontrel**
Common sowthistle (17) *	88	65	88	6	0	-	-	-	-	-
Bedstraw (3)	-	0	0	-	-	0	0	0	-	-
Bifora (3)	-	0	0	-	-	0	0	0	0	-
Marshmallow (4)	0	0	0	50	0	-	-	-	-	-
Wild turnip (2)	0	0	0	0	0	-	-	-	-	-
Wild radish (1)	0	0	0	0	0	-	-	-	0	-
IHM (1)	0	0	0	0	0	-	-	-	-	-
Medic (1)	0	0	0	0	-	-	-	-	-	0

** Figures in brackets are the number of samples tested*

In common sowthistle, over half of the biotypes exhibited resistance to SU and IMI herbicides (Table 2). The majority of SU resistant populations exhibited cross-resistance to imazapic (93% of samples) and Intervix® (imazamox + imazapyr) (73% of samples). Only one population was confirmed to be susceptible to both SU and IMI. All common sowthistle populations from paddocks with high IMI-use history were resistant to imazapic, and 69% were resistant to Intervix. Fifty percent of populations from paddocks with non-IMI history were resistant to both IMI herbicides.

The target site of all Group B herbicides is the enzyme acetolactate synthase (ALS). Multiple target-site mutations in the ALS gene have been confirmed in resistant weeds, conferring resistance across chemical families of ALS-inhibiting herbicides (Tranel and Wright 2002). ALS target site cross-resistance to SU and IMI was observed in common sowthistle and is of concern for the sustainability of HBCI rotations dominated by IMI tolerant PBA Hurricane XT lentil and Clearfield canola varieties. One population of common sowthistle from the Mid-North was also found to be resistant to the Group I herbicide 2,4-D and exhibited weak cross-resistance to IMI.

The herbicide resistance screening results identified that IMI herbicides were still effective in controlling other broadleaf weed species such as bedstraw, bifora, marshmallow, wild radish, wild turnip, Indian hedge mustard and medics (Table 2). However, an increased reliance on herbicide tolerant break crops, including IMI-tolerant pulse and canola varieties, without incorporating alternative weed control strategies, could result in weed species shifts and increased resistance in existing species. To address these issues, a project with joint investment of GRDC and SARDI has been initiated to develop effective management strategies, including integrated weed management practices for grasses and broad leaf weeds, to maintain the sustainability of HBCI systems.

Managing dim-resistant ryegrass in lentils – field trials

Two research trials were conducted during 2017 at the Hart (Mid-North) and Maitland (Yorke Peninsula) investigating the pre-emergent herbicide Ultro® (1700 g/ha with active carbetamide, Group E) which is currently in development. Ultro® was compared to propyzamide (900 g/kg @ 1000 g/ha), Sakura (118 g/ha) and Boxer Gold (2500 mL/ha) in controlling dim-resistant ryegrass in lentil. PBA Hurricane XT lentils were sown on 31 May 2017 at Hart and on 6 June 2017 at Maitland. At Hart, dim-resistant annual ryegrass seed was broadcast at 160 seeds/m^2 ahead of seeding and incorporated prior to herbicide application. The Maitland site had a background population of dim-resistant annual ryegrass.

The effectiveness of pre-emergent herbicides was investigated at both sites. Herbicide strategies including propyzamide resulted in the lowest ryegrass heads and seed set at both locations. Ultro® provided a 98% reduction in ryegrass seed set over unweeded control at both sites, and was similar to propyzamide, Sakura and Boxer Gold (Table 3). Additionally, Ultro® did not impact yield of lentil compared to propyzamide, Sakura and Boxer Gold. The pending registration of this new mode of action herbicide (Group E) is expected in 2020 and is likely to be an important tool, along with Group D propyzamide, in reducing selection pressure for existing Group J and K pre-emergent and dim chemistry post emergent herbicides for ryegrass control in break crops.

¤*Unregistered herbicide was included for experimental purposes only. It has been submitted to the APVMA for registration.*

Table 3. Ryegrass seed heads and seed set at maturity, and lentil yield at Hart and Maitland, in 2017. Numbers with different letters are significantly different averages (P<0.05).

Herbicide	Hart 2017			Maitland 2017		
	Head counts (heads/m^2)	RG seed set (seeds/m^2)	Yield (t/ha)	Head counts (heads/m^2)	RG seed set (seeds/m^2)	Yield (t/ha)
Ultro (IBS)* + Clethodim (POST)	6.5^b	352^b	1.95^a	4.8^b	269^b	3.62^a
Boxer Gold (IBS) + Clethodim (POST)	9.4^b	440^b	1.98^a	28.1^b	1697^b	3.39^a
Sakura (IBS) + Clethodim (POST)	10.2^b	549^b	2.02^a	9.6^b	585^b	3.85^a
Propyzamide (IBS) + Clethodim (POST)	4.9^b	120^b	1.86^a	0.5^b	23^b	3.71^a
Control	203.8^a	15364^a	1.38^b	179.6^a	13595^a	2.66^b

** Unregistered herbicides were included for experimental purposes only. The results within this document do not constitute a recommendation for that particular use by the author or author's organisation.*

Herbicides and crop-competition for managing vetch in Group B tolerant faba bean

A trial was established at Turretfield Research Centre in 2017, focusing on control of vetch and medic in Group B tolerant faba bean variety PBA Bendoc⍉. This trial was sown on 19 June 2017 in factorial randomised block design and included all combinations of three herbicide management strategies [H_1: Simazine (1100 g/ha) post-sowing pre-emergent (PSPE), H_2: Simazine (1100 g/ha) PSPE + Intervix® (750 ml/ha) at 5-6 crop node stage, and H_3: no herbicides] and three faba bean densities (12, 24 and 36 plants/m^2). Vetch seeds were broadcast prior to sowing @ 50 seeds/m^2 to contribute to the existing background medic weed population. The main effects of herbicide management strategies and faba bean densities are summarised in Table 4, and the interactions between these two factors were non-significant.

The Group B tolerant faba bean PBA Bendoc⁽ᵇ⁾ provided an opportunity to selectively use post-emergent Intervix® at 5-6 node stage. Application of simazine (PSPE) + Intervix® (post-emergent) resulted in a reduction in vetch seed and medic pod density by 97% and 100% respectively over grower practice (simazine 1100 PSPE) (Table 4). Improved broadleaf weed control with simazine (PSPE) + Intervix® (post-emergent) also resulted in the highest faba bean yield. These results indicate the availability of PBA Bendoc⁽ᵇ⁾ will benefit in selectively controlling vetch, medic and potentially other broad leaf weeds with post-emergence applied IMI in a strategy to minimise selection for resistance.

Table 4. Vetch and medic management in Group B tolerant faba bean (Bendoc) at Turretfield Research Station in 2017. Numbers with different letters are significantly different averages (P<0.05).

Treatment		Crop biomass at flowering (t/ha) 100 DAS	Plant height at flowering (cm) 100 DAS	Vetch pods/ plant 120 DAS	Medic pods/ plant 120 DAS	Vetch seed set/m^2	Medic pod set/m^2	Grain yield (t/ha)
Herbicide								
H_1	Simazine 1100 (PSPE)	2.46^{ab}	59.3^{b}	11.7^{b}	19.2^{b}	930^{b}	61^{b}	2.66^{b}
H_2	Simazine 1100 (PSPE) + Intervix* 750 (at 5-node stage)	2.78^{a}	58.4^{b}	1.8^{c}	0.0^{c}	25^{c}	0^{c}	3.19^{a}
H_3	Unweeded control	2.17^{b}	62.0^{a}	15.9^{a}	75.3^{a}	1399^{a}	2421^{a}	2.14^{c}
Density (m^{-2})								
D_1	12	1.13^{c}	52.2^{c}	12.4^{a}	53.0^{a}	772^{a}	745^{a}	1.92^{c}
D_2	24	2.55^{b}	59.1^{b}	9.7^{b}	27.1^{b}	660^{a}	289^{b}	2.83^{b}
D_3	36	3.72^{a}	68.4^{a}	7.3^{b}	14.3^{c}	380^{b}	161^{b}	3.25^{a}

**Unregistered herbicides were included for experimental purposes only. The results within this document do not constitute a recommendation for that particular use by the author or author's organisation. Currently there is a permit (PER14726) to use imazamox (700 g/kg product @ 45 g/ha or 350 g/kg product @ 90 g/ha at 3-6 node stage) in Group B tolerant faba bean (Bendoc).*

Crop competition has been shown to complement other weed control strategies. An increase in break crop plant density can lead to early ground cover, thereby reducing the competitiveness and seed production of weeds (Lemerle et al. 2006). The implementation of such a strategy can be especially effective in crops such as faba bean that have low plant densities and slow initial growth. In the present study, increasing faba bean density from 12 to 36 plants/m^2 resulted in improved crop competition with weeds due to significant increase in crop biomass and plant height (Table 4). The increased crop competitiveness significantly reduced vetch pods and seed set, and medic pod set, and subsequently led to increased crop yield (Table 4). A faba bean density of 36 plants/m^2 resulted in 42% and 44% reduction in vetch seed and medic pod set respectively, compared to standard grower practice of 24 plants/m^2. There was no disease incidence or lodging with an increase in faba bean density at the trial site in 2017. This practice requires further investigations across different seasons and locations.

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DAS00168-BA

Canola tolerance to clethodim

Sarah Noack, Hart Field-Site Group

Key findings

- Grain yield losses were caused by clethodim at particular rates and application timings.
- Early application timings were the best to avoid crop damage.
- Variation does exist between herbicide tolerant canola types (conventional, Clearfield and triazine tolerant).

Why do the trial?

In 2013 and 2014 trials were established at Hart to assess the level of yield losses that may occur from the use of high clethodim rates in canola (Zerner 2014). Observed crop damage symptoms included delayed flowering, distorted flower buds and grain yield suppression. Symptoms were more severe from later application timings. Another key finding was that variation existed between herbicide tolerant crop types (conventional, Clearfield and triazine tolerant) and their level of sensitivity to clethodim.

In the past four years we have seen a number of new canola varieties become commercially available. In 2017 clethodim damage was reported by a large number of consultants and growers. The current trial aimed to:

1. assess new canola varieties for their tolerance to clethodim and
2. demonstrate to growers the potential yield losses that may result from high and late applications of clethodim.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) + Zn 2% @ 100 kg/ha
Seeding date	15th May 2018		UAN (42:0) @ 95 L/ha on 5th July
			UAN (42:0) @ 55 L/ha on 2nd Aug

The trial was established as a split-plot design with three replicates. Three canola varieties were used; Nuseed Quartz (conventional), Hyola 559TT (triazine tolerant) and Pioneer 44Y90 (CL) (Clearfield) to investigate the influence of clethodim rate and timing. Seven clethodim treatments were applied to each variety (Table 1).

Spray treatments for each growth stage were applied on the same day for each variety. As a result the exact growth stage at the time of application for each variety may have differed slightly, despite all varieties used in this trial being of very similar maturity. All plots were assessed for grain yield at harvest.

Table 1. Clethodim treatments applied at Hart during 2018.

Clethodim rates applied
1. Untreated control
2. 0.5 L/ha applied at 4-leaf growth stage
3. 1.0 L/ha applied at 4-leaf growth stage
4. 0.5 L/ha applied at 8-leaf growth stage
5. 1.0 L/ha applied at 8-leaf growth stage
6. 0.25 L/ha applied at 4-leaf and 8-leaf growth stages (0.5 L/ha in total)
7. 0.5 L/ha applied at 4-leaf and 8-leaf growth stages (1 L/ha in total)

**Application of clethodim at 1 L/ha is not a registered rate and was undertaken for experimental purposes.*

Results and discussion

Overall canola crop damage was less severe compared to the damage reported in 2013 and 2014. This can be attributed to a range of factors including; environmental conditions at time of application, the absence of the late clethodim application timing (bud initiation) this season and the use of alternative canola varieties. A range of damage symptoms were observed in-season (Figure 1). There were no visual changes in overall crop biomass or any significant change in NDVI between treatments in this particular trial (data not shown). As the crop further developed to reach flowering the damage symptoms become more evident. Flower buds become distorted and failed to open up fully leading to poor pod development (Figure 1). In these plots flowering date was also delayed.

Figure 1. Pioneer 44Y90 (CL) canola displaying damage symptoms caused by 1.0 L/ha clethodim at 8-leaf growth stage. Distorted flowers did not fully open and form pods.

Observed clethodim damage resulted in grain yield losses in some varieties (Table 2). Overall there was no interaction between variety, clethodim rate and application timing. However, individually these management factors impacted canola grain yield. Of the varieties tested the conventional variety Nuseed Quartz and triazine tolerant Hyola 559TT showed a greater level of tolerance to clethodim. The Clearfield variety 44Y90 (CL) on average incurred a 11% (ranged from 7 – 29%) yield loss from application of clethodim. This finding is consistent with previous research (Zerner 2014) where the Clearfield variety Hyola 474 CL was the most sensitive to clethodim.

Application rates of 0.5 L/ha were relatively safe in this trial and were not significantly different from the unsprayed control for any variety. Where rates were increased to 1.0 L/ha the average yield reduction across all three varieties was 9%. Application of clethodim at 1.0 L/ha is not a registered rate and was undertaken for experimental purposes.

Early sprays (4-leaf growth stage) had no significant implications on grain yield (Table 2). Yield reductions (average 12%) were observed at the 8-leaf growth stage. In previous research (Zerner 2014) the effect of clethodim at the 8-leaf application was inconsistent. In 2013 damage was observed at the 8-leaf growth stage however, in 2014 this timing did not cause any significant yield reduction. The split application appeared to improve the safety of the 1.0 L/ha treatment (Table 2) when it was applied over two applications rather than in one.

Table 2. Effect of clethodim applied at different timings and rates on the grain yield of canola at Hart, 2018. (LSD P≤0.05 variety 5.5; clethodim rate 4.5; and timing 5.5).

Application timing	Clethodim rate	Hyola 559TT	Nuseed Quartz	44Y90 (CL)
Untreated		1.09	1.31	1.17
		grain yield % of control		
4 leaf	0.5 L/ha	100	97	93
	1.0 L/ha	94	97	91
8 leaf	0.5 L/ha	95	94	90
	1.0 L/ha	89	86	71
Split 4 leaf + 8 leaf	0.25 L/ha + 0.25 L/ha	100	100	100
	0.5 L/ha + 0.5 L/ha	99	98	90

Summary

Increased application rates of clethodim have created concern due to crop damage in canola, which is the most sensitive crop of those registered for clethodim use. Care should be taken to apply clethodim at correct growth stages and application rates on label.

Applications exceeding 0.5 L/ha are at high risk of causing yield reductions in most canola varieties. Variation does exist between herbicide tolerant canola types (conventional, Clearfield and triazine tolerant). From the trial results it is evident that the early application at 4-leaf growth stage of canola was the safest on the crop but this may not be always the best time of application for targeting weed control.

References

Zerner M (2014) Canola tolerance to clethodim. Hart Trial Results book, page 59 – 61.

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Ascochyta blight severity and yield response to fungicides in field pea

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Key findings

- Understanding the key drivers of ascochyta blight (AB) disease in field pea, such as the level of starting inoculum and seasonal conditions pre and post sowing, is crucial to effective and economical management of this disease.
- In high disease risk seasons, foliar fungicides applied either before, or at the first sign of disease, and a follow up spray at early flowering reduced further spread.
- An additional foliar spray during spring may be required when wet and cool conditions cause late season infection on new growth.
- Recently registered products for AB on field peas demonstrated greater disease control and yield gain than older products.
- Disease control and yield improvement responses to fungicides have been observed where yield potential is >1.5 t/ha. Below that threshold, responses are generally not measurable and fungicides may not be economical.

Why do the trial?

Ascochyta blight (AB) (blackspot) is a serious disease in field pea associated with significant yield reductions if not managed. It is caused by fungi originating from infected field pea stubble, soil borne inoculum, or diseased seed. Pre-sowing rainfall conditions in summer and autumn influence spore maturation on the stubble, the timing of spore release and the risk of blackspot infecting an establishing crop. Once mature, the spores are transported by wind and rain onto a crop where infection begins. Severity of AB depends on the level of inoculum and the seasonal conditions including duration of in-crop rainfall and sometimes dew.

The current trial work was part of a four year research program that was conducted by SARDI under the Southern Pulse Agronomy project (SPA) funded by the GRDC (DAV00150). So far, our research has developed an improved fungicide strategy using recently registered products targeting early disease control at the 4-6 node growth stage. The aim of the current research was to evaluate the efficacy of new foliar fungicide actives applied as standalone in comparison to their combinations with a seed treatment. This information will provide new insight into the role of the seed dressing and the performance of new fungicides in managing AB disease in field pea.

How was it done?

Three years (2016 - 2018) of experimental field trials were conducted in low (Minnipa, Upper Eyre Peninsula), and medium (Hart, Mid-North) rainfall environments in SA. A number of fungicide treatments were tested and applied as shown in Table 1.

In 2016 and 2018 the trials at Hart and Minnipa were designed as randomized complete block design, with three replications. In 2017, a time of sowing experiment was conducted at Hart only. The aim was to simulate sowing under high and low disease risk, and evaluate the efficacy of the fungicides on disease control and yield response. PBA Coogee was used in 2016 and PBA Oura in 2017 and 2018, sown at 55 plants/m^2.

AB infected field pea stubble was incubated to achieve maximum or minimum AB spore maturation pre-sowing. The incubated stubble was spread on trials to ensure disease infection. Table 2 presents the dates at which the trials were sown and the corresponding disease assessment dates. Disease severity was assessed as the percentage plant area diseased (purplish-black necrotic lesions on leaves) by frequency of infected plants per plot. Plots were machine harvested and grain yields recorded for each treatment at physiological maturity.

Table 1. Fungicide treatments and application timings in field pea blackspot management trials conducted at Hart and Minnipa in 2016-2018.

Year and site	Fungicide treatments	Fungicide application timing
2016 Hart & Minnipa	Nil PPT® Mancozeb® (plus PPT) Chlorothalonil® (plus PPT) Aviator Xpro® (plus PPT) Aviator Xpro® (plus PPT) + mancozeb	Nil Seed treatment 6 WAS + early flowering Fortnightly 6 WAS + early flowering 4 Node + early flowering + mancozeb at podding
2017 Hart	Nil PPT® Mancozeb® (plus PPT) Chlorothalonil® (plus PPT) Aviator Xpro® (plus PPT) Aviator Xpro® (plus PPT) + mancozeb	Nil Seed treatment Early disease sighting (occurred at 8 node) + early flowering Fortnightly Early disease sighting (occurred at 8 node) + early flowering 4 Node + early flowering + mancozeb at podding
2018 Hart and Minnipa*	Nil Chlorothalonil® (plus PPT) Aviator Xpro® (minus PPT) Aviator Xpro® (plus PPT) Veritas® (minus PPT) Veritas® (plus PPT) Aviator Xpro® (plus PPT) + mancozeb	Nil Fortnightly 4 Node + early flowering Early disease sighting + early flowering 4 Node + early flowering Early disease sighting + early flowering Early disease sighting + early flowering + mancozeb at podding

#All fungicide treatments were treated with Apron® (350 g/L Matalaxyl-M) seed dressing to control downy mildew

Notes:

- In 2018, disease occurred earlier at Hart (4 node growth stage) and as a result, the fungicides which were to be applied at early disease sighting were also applied at the 4 node growth stage. At Minnipa, disease was light early in the season and the earliest fungicides were applied at 4 node while the fungicide which were to be applied at 'early disease sighting' were applied at 6 node growth stage.
- In 2018, a final disease rating (disease index) was not conducted at Minnipa as not much rainfall was recorded post September 4.

Table 2. Sowing date and disease assessment dates in field pea blackspot management trials conducted at Hart and Minnipa in 2016-2018.

Year	Site	Sowing date	Growth stage and date at disease severity assessment	Growth stage and date at disease index assessment
2016	Hart	10-May	13 Node (July 27)	Flowering (Sep 1)
	Minnipa	6-May	13 Node (July 29)	Flowering (Aug 31)
2017	Early sowing, Hart	27-Apr	14 Node (July 12)	Flowering (Aug 29)
	Delayed sowing, Hart	31-May	17 Node (August 29)	Flowering (Oct 19)
2018	Hart	8-May	19 Node (Aug 22)	Flowering (Sept 3)
	Minnipa	28-May	17 Nodes (Sept 4)	Not scored

Seasonal conditions and disease severity over three years

In 2016, the growing season rainfall (GSR) was above long-term average at Minnipa and Hart (Figure 1 and Figure 2). The two trials were sown in late autumn into relatively dry seed bed conditions. This was followed by wet conditions that allowed AB establishment and progression in winter and a relatively cool spring which lengthened the crop growing season, particularly at Hart. The prolonged growing season at Hart resulted in late disease infection at this site.

The 2017 season started with a late break in most parts of SA occurring in mid-April to mid-May at Hart and mid-July at Minnipa. As a result, a sowing time field pea trial was only at Hart. Growing season and annual rainfall were well below the long-term annual average for Hart (Figure 1). Early AB infection and progression was low due to an extended dry period during the growing season. However, high rainfall events occurred in late winter/early spring and favoured disease spread in the latter growing stages. Severe frost events occurred in the last week of August, which coincided with the critical development period of pod filling in the early sown crops.

In 2018, weather conditions were extremely dry over summer and autumn (Figure 1 and Figure 2). The dry start to the season meant that there was a delay in maturation of the stubble borne fungal spores and spore release occurred in late autumn at Hart and early winter at Minnipa when the opening rains occurred. Growing seasonal rainfall (GSR) was well below the long term average GSR at both sites with most of the in-crop rainfall falling in the month of August. Significant frost events occurred through the months of July to October at Hart. The sustained dry seasonal conditions influenced crop establishment and reduced the progression of AB during the 2018 cropping season.

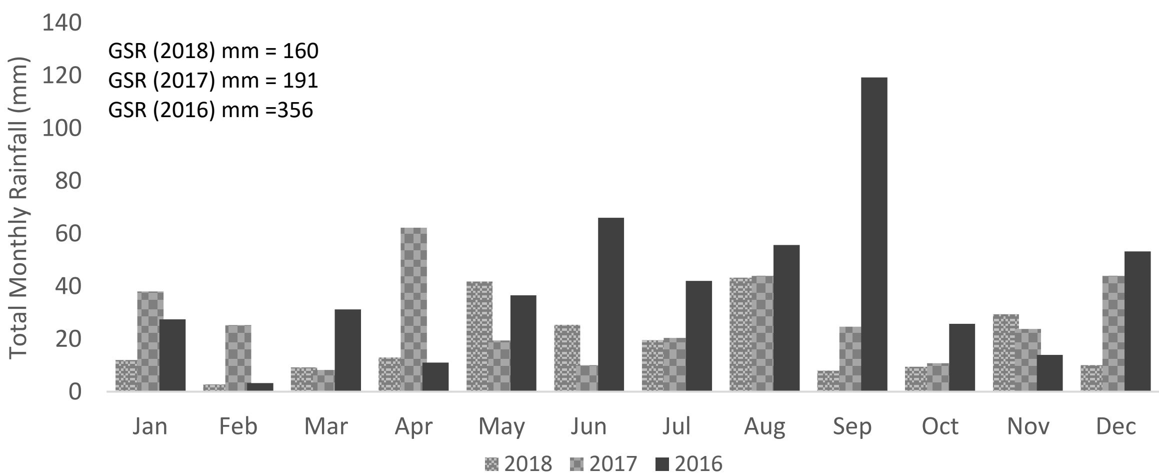

Figure 1. Total monthly rainfall (mm) over a three-year (2016 - 2018) period at Hart (Mid-North, SA).

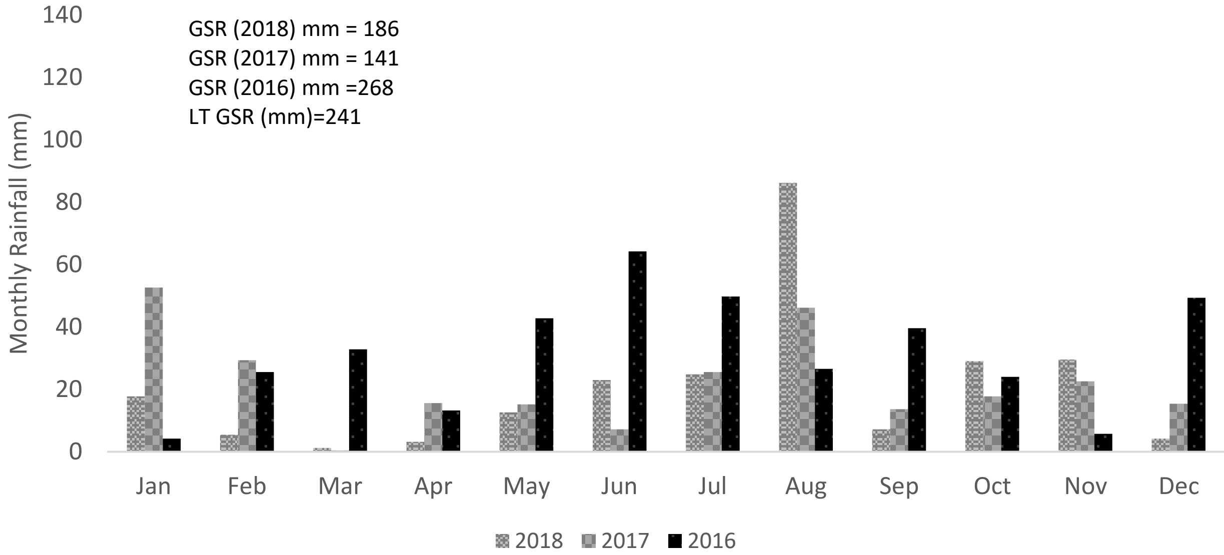

Figure 2. Total monthly rainfall (mm) over a three-year (2016 - 2018) period at Minnipa (Upper Eyre Peninsula, SA).

Results and discussion

Disease severity and yield responses from fungicide application

Results showed a complex interaction between AB and environment (sites and seasonal conditions) and the response in disease control and yield improvement from fungicide application. In some seasons in the low rainfall site, disease occurred earlier and was more severe than the medium rainfall environment. As such, application timing and type of product was important where disease occurred earlier.

2016 and 2017 Results

In 2016, above average rainfall favoured early and high disease severity at Minnipa prior to the first foliar applied at 6 weeks post sowing. In contrast, at Hart, there was low disease severity early in the season. The above average spring rainfall and cooler conditions resulted in extended crop growth and meant that the crop was exposed to late AB infection. Consequently, there was a significant site interaction for disease severity and grain yield responses to the fungicide treatments. The mancozeb applications reduced AB severity compared to the nil at Hart but not at Minnipa (Table 3) most likely due to the differences in early disease establishment. No significant yield gains were associated with this product (Table 3). Two sprays of Aviator Xpro® significantly reduced disease scores at Hart but not at Minnipa. Aviator Xpro® recorded significant yield gains over the nil treatment at both sites (Table 3). The highest yields were associated with two sprays of Aviator Xpro® and fortnightly sprays of chlorothalonil (Table 3). In comparison to mancozeb, Aviator Xpro®, showed yield benefits of at least 19 % across the two sites under high disease severity.

In 2017, early AB disease onset and progression in the Hart time of sowing trial was low due to an extended dry period during the growing season and non-conducive environmental conditions. AB leaf spotting was first noted at 8 node growth stage. High rainfall events occurred in late winter/early spring (Figure 1) and may have favoured disease spread in the later growing stages. The fungicide treatments had a significant effect on disease severity and disease index (Table 4), but there was no interaction with sowing date. All fungicide treatments, except mancozeb, significantly reduced disease compared to the untreated plots. Grain yields increased up to 15% from the use of the new products over mancozeb in the early sown plots at Hart in 2017 (Table 4). The three spray strategy of Aviator Xpro® at 4 node growth stage, early flowering followed by a late spray of mancozeb at podding produced similar yields to fortnightly chlorothalonil in the early sown plots, a 25% increase over the untreated plots (Table 4). In contrast, this response was not found in 2016 (Table 3), where fortnightly Chlorothalonil had higher yields than the three spray strategy. This may be due to a number of Chlorothalonil sprays being applied in seasons with more favourable and wetter finishing conditions. Although 2017 was generally a drier year, a substantial amount of rain fell in late winter/early spring and the late spray of mancozeb in the Aviator Xpro® treatment was beneficial in controlling the spread of AB resulting in yield increases in early sown crops similar to the fortnightly treatment. In the later sowing, there was no yield response to fungicides and a yield penalty of approximately 1 t/ha was observed across all treatments compared to early sown plots (Table 4).

Table 3. Ascochyta blight disease severity (% plot severity) assessed at between 9 and 13 node growth stage and grain yield under different fungicide treatments at Hart and Minnipa, 2016.

Fungicide treatments	**Fungicide application timing**	**Disease severity (%)**		**Grain yield (t/ha)**	
		Hart	**Minnipa**	**Hart**	**Minnipa**
Nil	Nil	32	51	1.49	0.95
Mancozeb (plus PPT)	6 weeks after sowing + early flowering	24	47	1.54	1.19
Aviator Xpro® (plus PPT)	6 weeks after sowing + early flowering	24	46	1.93	1.40
Aviator Xpro® (plus PPT) + mancozeb	4 Node + early flowering + mancozeb at podding	17	42	1.65	1.58
Chlorothalonil® (plus PPT)	Fortnightly	14	25	2.67	1.67
LSD (P<0.05) Fungicide x site		7.8		0.34	

Table 4. Ascochyta blight disease severity (% plot severity) assessed at between 9 and 13 node growth stage in field pea (PBA Coogee) under different fungicide treatments at Hart (Mid-North, SA) in 2017.

Fungicide treatments	**Fungicide application timing**	**Disease severity (%)**	**Grain yield (t/ha)**	
			27 April	**31 May**
Nil	Nil	55	2.66	2.28
Mancozeb (plus PPT)	Early disease sighting (occurred at 8 node) + Early flowering	48	2.76	2.31
Aviator Xpro® (plus)	Early disease sighting (occurred at 8 node) + Early flowering	39	3.22	2.33
Aviator Xpro® (plus PPT) + mancozeb	4 Node + Early flowering + mancozeb at podding	37	3.42	2.19
Chlorothalonil® (plus PPT)	Fortnightly	2	3.53	2.29
LSD (P<0.05) Fungicide		8.1		
LSD (P<0.05) Fungicide x sowing time			0.19	

2018 Results

Compared to 2016 and 2017, AB infection was low in 2018 at both locations. Early disease severity was slightly higher at Hart with early leaf spotting sighted on all 4 nodes prior to the first spray application (Table 5).

At Minnipa AB leaf spotting started to appear at 6 node growth stage. It is worth noting that the 4 node fungicide treatments had already been applied prior to this early disease sighting at Minnipa. Hart had slightly more intermittent in-season rainfall at the start of the season, which may have contributed to early disease spread. In contrast, rainfall was delayed at Minnipa with majority of rain occurring in August (Figure 2).

At Hart, the disease index, assessed at mid-podding, was significantly reduced by all fungicide applications compared to the nil treatment (Table 5). Plots sprayed with chlorothalonil every fortnight had the lowest disease scores at the both assessment periods compared to all other treatments (Table 5). There was a reduction in disease severity from 4 of the foliar fungicides compared to the nil treatment at Hart (Table 5). Foliar fungicides with and without PPT had the same responses in disease severity at Hart. This indicates PPT did not reduce AB disease severity when using foliar fungicides at an early growth stage.

At Minnipa, all fungicide treatments had significantly less disease than the nil treatment. Both Aviator Xpro® and Veritas® gave the same level of response with or without PPT (Table 6).

No significant yield gains were associated with the treatments at either site, most likely due to the dry seasonal conditions that limited the spread of disease and lowered yield potential.

Table 5. Ascochyta blight disease severity (%) assessed at early flowering, disease index (%) assessed at mid-podding growth stages and mean grain yield (t/ha) of field pea (PBA Oura) under different fungicides at Hart (Mid-North, SA), 2018.

Fungicide Treatment	Fungicide application timing	Disease Severity (%)	Disease Index (DI) (%)	Grain yield (t/ha
Nil	Nil	37	68	1.41
Aviator Xpro® (plus PPT) + mancozeb	Early disease sighting (occurred at 4 node) + early flowering	34	56	1.44
Aviator Xpro® (plus PPT)	Early disease sighting (occurred at 4 node) + early flowering	33	51	1.45
Aviator Xpro® (minus PPT)	4 node + early flowering	31	48	1.39
Veritas® (minus PPT)	4 node + early flowering	31	51	1.38
Veritas® (plus PPT)	Early disease sighting (occurred at 4 node) + early flowering	31	51	1.32
Chlorothalonil® (plus PPT)	Fortnightly	5	20	1.56
LSD		4.8	7.0	ns

NB: Both fungicides scheduled at 4 node and at early disease sighting were applied at 4 node growth stage which was also when the initial AB spotting was observed.

Table 6. Ascochyta blight disease severity (%) assessed at early flowering, Disease index (%) assessed at mid-podding growth stages and mean grain yield (t/ha) of field pea (PBA Oura) under different fungicides at Minnipa (upper Eyre Peninsula, SA), 2018.

Fungicide Treatment	Fungicide application timing	Disease Severity (%)	Grain yield (t/ha)
Nil	Nil	32	1.11
Aviator Xpro® (plus PPT) + mancozeb	Early disease sighting (occurred at 6 node) + early flowering	21	1.20
Aviator Xpro® (plus PPT)	Early disease sighting (occurred at 6 node) + early flowering	17	1.23
Aviator Xpro® (minus PPT)	4 node + early flowering	13	1.19
Veritas® (minus PPT)	4 node + early flowering	18	1.14
Veritas® (plus PPT)	Early disease sighting (occurred at 6 node) + early flowering	21	1.06
Chlorothalonil® (plus PPT) (fortnightly)	Fortnightly	18	1.14
Lsd		9.8	ns

NB: The 4 node fungicide treatment was applied at this growth stage while the 'early disease sighting' fungicide treatment was applied at the 6 node growth stage when leaf spotting was first observed.

Summary of key findings

This study has led to a better understanding of some of the principles underlying management of AB disease in field peas and has developed strategies for growers.

Manipulating sowing time – The ideal sowing time to minimise AB in field pea is when the majority, at least 60% of AB spores, have been released from infected stubble prior to crop emergence. This information can be obtained from the Blackspot manager. Spore release varies depending on summer and autumn conditions

Fungicide use – Fungicides play an important role in controlling AB progression in-season. Our results show that early sowing in high disease situations with no fungicides will result in significant yield losses. The response from fungicide use is complex and may not always be economic as disease severity varies from season to season.

- In seasons where disease established early (by 4 node growth stage) a foliar application with mancozeb (2kg/ha) at the 9 node growth stage was too late for effective disease control. Application of Aviator Xpro® at 4 node growth stage showed greater efficacy.
- Where disease severity was not initially severe early in the season, mancozeb (2 kg/ha) reduced disease over the nil, however there were no yield improvements.
- Early sprays with new fungicides at 4 node showed greater efficacy in controlling disease and improving yield compared to those applied at 9 nodes.
- New fungicides were effective in reducing disease and improving yields in early sown crops and in high disease situations (>50 % disease severity) sustained by wet in-crop growing conditions and yield potentials of >1.5 t/ha. These conditions were achieved both in 2016 and 2017.
- A three-spray strategy of Aviator Xpro® at 4 node growth stage, early flowering followed by a late spray of mancozeb at podding spray may be required for high yielding crops in wetter spring conditions that extend late season disease infection on new growth. Therefore, a late spray at podding may be required to prevent AB pod and seed infection.

Acknowledgements

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Tracking mouse activity across the Mid-North

Emma Pearse and Sarah Noack, Hart Field-Site Group
Steve Henry, CSIRO Health and Biosecurity Canberra

Key findings

- High mouse numbers were measured in autumn 2018, following an outbreak of numbers in the previous season.
- Mouse numbers decreased significantly by winter and remained low due to good baiting programs and very dry conditions in-season.
- The MouseAlert website is a useful tool to check mouse populations near your region.

Why do the paddock survey?

Mouse populations in cropping regions can increase rapidly leading to widespread crop damage and reduced yields. During the 2017 season many areas in the Mid-North observed high mouse populations. This resulted in growers using multiple applications of bait and in some cases having to re-sow paddocks. Reports of mouse damage were still occurring in spring during flowering and grain fill. These events made the monitoring of mouse numbers a priority in early 2018.

Mouse populations can be difficult to reduce once high as there is only one recognised toxin for control of mice for broad scale application. Baiting with zinc phosphide is the most effective method with research indicating that 90-95% of mouse populations were killed when baits were dispersed at the rate of 1 kg/ha (GRDC 2017). While this is an effective control method it can become costly, making it critical to understand when to time your baiting program. CSIRO are leading research, funded by GRDC, into monitoring mouse populations across Australia to better understand and prepare for potential plagues. They have created a free and interactive website and phone App called MouseAlert to map and monitor mouse numbers across all Australian grain growing regions.

How was it done?

Mouse populations were monitored on three occasions throughout 2018; on the 12th April, 27th June and the 6th September to capture autumn, winter and spring numbers (critical times to determine changes in mouse populations). The same six paddocks along a 100 km transect from Halbury to Crystal Brook were targeted at each monitoring event (Figure 1).

At each site mouse holes were identified and marked with cornflour along four 100 m long x 1 m wide transects (aligned parallel with furrows and set 20 m apart). These were assessed for activity the following day by the presence of mouse tracks. Chew cards soaked in canola and linseed oil were positioned every 10 m along one transect and collected the following day. The portion (as a percentage) of card chewed by mice was recorded.

Figure 1. Map of the six paddocks visited at each monitoring event from Halbury to Crystal Brook.

Results and discussion

Autumn monitoring indicated mouse populations were high across all six sites in the Mid-North. The highest number of active mouse holes were observed at Kybunga with 2,125 active mouse holes/ha (Table 1). The ranking of the severity of outbreak based on active mouse holes/ha is included in Table 2. These rankings are a guide only, always be vigilant and if your mouse population increases to 100 holes/ha or above take action immediately to reduce further risk. Details on control strategies can be found on GRDC GrowNotes^{TM}:
https://grdc.com.au/__data/assets/pdf_file/0021/243804/GRDC-Tips-and-Tactics-Better-Mouse-Management-National-2017-high-res.PDF

The lowest recording was 75 active mouse holes/ha at Condowie while the other four sites ranged between 200 – 750 active mouse holes/ha (Table 1). High numbers were expected after a high yielding season in 2017 provided high stubble loads for shelter and dropped grain for feed.

Table 1. Average number of marked and active mouse holes per ha across the six farms in the Mid-North in 2018.

Location	Average Marked holes/ha			Average Active holes/ha		
	Autumn 12/4/2018	Winter 27/6/2018	Spring 6/9/2018	Autumn 12/4/2018	Winter 27/6/2018	Spring 6/9/2018
Halbury	1425	75	75	750	0	75
Kybunga	2550	0	0	2125	0	0
Condowie	425	100	125	75	25	0
Brinkworth	625	50	375	200	0	0
Koolunga	425	0	0	225	0	0
Crystal Brook	1475	125	150	450	75	25

Table 2. Ranking of the severity of the number of active mouse holes per ha.

Active mouse holes/ha	Ranking
0-75	Low
75-300	Moderate
300-1000	High
>1000	Very High

Winter sampling saw a significant drop in the mouse population across all sites. For many paddocks the numbers were low and for growers with higher populations baiting programs were sufficient to reduce the number of mice. Burrow counts ranged from 0 – 75 active mouse holes/ha with the highest counts in Crystal Brook (Table 1). These numbers remained low as the season moved into spring with burrow counts again ranging from 0 – 75 active mouse holes/ha. The overall reduction in burrow counts and associated reduction in mouse numbers is largely driven by a combination of significant baiting activity by farmers at sowing and exceptionally dry conditions experienced across many areas. Breeding begins in spring so although recorded numbers were low it will be important to keep track of populations post-harvest and to bait accordingly for the upcoming 2019 season.

Management recommendations to prevent increases in mouse numbers are outlined below (CSIRO Mouse Alert, 2018):

1. Keep on top of weed control along fence lines before weed seed set.
2. Store grain and stockfeed in mouse-proof areas.
3. Bait around buildings where necessary.
4. Keep monitoring any mouse activity and numbers in paddocks.

Summary / implications

Currently mouse numbers have declined and are low in most areas. It is expected the mouse population density will remain low coming into seeding in 2019.

Mouse numbers can change quickly across regions and throughout seasons. The Mouse Alert website is a quick and easy way to assess the risk of damaging numbers in your particular area. While baiting is the most effective method to control mouse populations there are other simple measures to make sure that risk is managed and kept low, as outlined on the GRDC GrowNotes™ and on the MouseAlert website. You can easily record your own mouse populations on the MouseAlert App to keep other farmers informed. To do so visit https://www.feralscan.org.au/mousealert/ or download the MouseAlert App from the App store.

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Acknowledgements

We gratefully acknowledge CSIRO for funding this monitoring in the Mid-North. Thank you to each of the participating farmers involved in this mouse monitoring survey.

Managing your fertiliser dollar in wheat and barley

Emma Pearse and Sarah Noack, Hart Field-Site Group

Key findings

- For La Trobe barley, 20 kg N/ha was sufficient to achieve the highest grain yield and a protein level for malt classification.
- Similarly in wheat, 20 kg N/ha was sufficient to achieve the highest grain yield in 2018. Greater rates of N were required to improve protein levels to achieve AH classification.

Why do the trial?

Management of nitrogen can have substantial impacts on final yield and quality of your crop. The two main grower questions with nitrogen (N) management are how much N needs to be applied and when should it be applied? The basis of most nitrogen management strategies is an N budget however decisions can often be 'reactive' to the season and can be based on previous experiences and attitude to risk.

The key components to N budgeting are target yield and protein, as crop yield potential is the major driver of N requirement. This trial is designed to look at nitrogen management strategies in wheat, barley and canola across multiple seasons. This is the second season that the trial has run. It will be run over one more season to total three seasons of data. The specific aims are to:

- Assess simple nitrogen management strategies to determine the best return on investment from fertiliser nitrogen applications.
- Determine within a crop rotation (wheat and barley) where your fertiliser dollar was best spent over a number of seasons.

How was it done?

Plot size	1.75 m x 10.0 m	**Fertiliser**	DAP (18:20) @ 60 kg/ha at seeding (equivalent to 10 kg N/ha)
Seeding date	15^{th} May 2018		In-season nitrogen rates Table 1

Each trial was a randomised complete block design. The trials were blocked separately by crop type (Scepter wheat and La Trobe barley). The trial also included 44Y90 canola however, the data cannot be presented due to significant bird damage to some plots.

Prior to sowing (16^{th} April) the trial area was assessed for available soil nitrogen (0-10, 10-30 and 30-60 cm). The total available soil nitrogen pre-seeding was 78 kg N/ha. All plots were assessed for grain yield and quality (protein, test weight kg/hL, retention % and screenings %).

Table 1. Nitrogen rates applied to wheat, barley and canola nutrition trials at Hart in 2018

Wheat	Barley	Canola
1. Nil 2. 80 kg N/ha @ seeding 3. 20 kg N/ha @ GS31	1. Nil 2. 80 kg N/ha @ seeding 3. 20 kg N/ha @ GS31	1. Nil 2. 100 kg N/ha @ seeding 3. 50 kg N/ha @ seeding + 50 kg N/ha @ rosette
4. 40 kg N/ha @ GS31	4. 40 kg N/ha @ GS31	4. 50 kg N/ha @ seeding + 50 kg N/ha @ rosette + 100 kg N/ha @ bolting
5. 80 kg N/ha @ GS31 6. 100 kg N/ha @ GS31 7. 200 kg N/ha @ GS31		5. 200 kg N/ha @ bolting

Results and discussion

Barley

The nitrogen rates trialed in La Trobe barley showed applying 20 kg N/ha at GS31 was sufficient to achieve the highest yield and protein to meet malt specification (Table 2). Applying 20 kg N/ha resulted in a 0.3 t/ha yield increase when compared to the nil treatment. Increasing the N rate above 20 kg/ha did not increase grain yield however, grain protein was increased where 80 kg N/ha was applied. This increase in grain protein was not advantageous as it exceeded 12% (the maximum required for malt 1). Applying 80 kg N/ha at seeding had the same yield and protein compared to if applied in season.

Grain screenings were not affected by the different nitrogen applications and were all below the 7% maximum for malt 1. All test weights were above the 65 kg/hL and retention above 70% minimum for malting classification. The low N rate required for maximum grain yield and quality in barley is not surprising this season, given the lower yield potential in a below average rainfall season.

Table 2. La Trobe barley grain yield and quality for the nitrogen treatments at Hart, 2018. Treatments shaded grey are not significantly different from the highest yielding/quality treatment.

Treatment	Yield t/ha	Protein %	Screenings %	Test Weight kg/hL	Retention %
Nil	2.64[a]	9.0[a]	0.8	71.6[c]	92.3[b]
80 kg N/ha @ seeding	2.96[b]	12.2[c]	2.1	70.0[a]	70.3[a]
20 kg N/ha @ GS31	2.96[b]	9.7[ab]	1.3	71.1[bc]	88.5[b]
40 kg N/ha @ GS31	3.01[b]	10.7[b]	1.5	70.6[b]	81.5[ab]
80 kg N/ha @ GS31	3.11[b]	12.4[c]	2.3	70.5[ab]	70.9[a]
LSD (P≤0.05)	0.17	1.5	NS	0.7	12.1

Wheat

Application of 20 kg N/ha was sufficient to achieve the highest wheat yield at Hart in 2018. There was no yield benefit when 40 kg N/ha up to 200 kg N/ha was applied in season. Where 80 kg N/ha was applied at seeding versus in-season, there was a slight yield advantage of applying N in-season (Table 4). However, delaying N applications in a dry season will not always achieve the desired response. The risk of the crop not accessing in-season applied N is high due to limited rainfall and soil moisture required for plant uptake.

As expected, higher rates of N (200 kg N/ha) increased grain protein up to 13.2%. A minimum of 80 kg N/ha (at seeding) or higher was required to achieve protein levels above 11.5% for H2 classification. Generally, at Hart we observe the 80 kg N/ha applied in-season resulting in a similar or higher protein level compared to the at seeding application. However, lack of rainfall and soil moisture would have caused reduced N uptake from the in-season application this season. The lowest protein levels in the trial were found in the chicken litter and biochar treatments. This is most likely due to the tie up of N as soil microbes breakdown these organic materials. Over time this N will become available through microbial mineralisation (release of N from dying microbes).

Grain screening levels were low across the trial, with all treatments below the 5% maximum. Test weights were high (>76 kg/hL) and did not differ between N application treatments.

Table 3. Scepter wheat grain yield and quality for the nitrogen treatments at Hart, 2018. Treatments shaded grey are not significantly different from the highest yielding/quality treatment.

Treatment	Yield t/ha	Protein %	Screenings %	Test Weight kg/hL
Nil	2.24^{c}	8.4^{ab}	0.9^{b}	80.1
80 kg N/ha @ seeding	2.54^{bc}	11.6^{de}	0.9^{b}	79.6
20 kg N/ha @ GS31	2.67^{abc}	9.3^{bc}	1.1^{b}	80.3
40 kg N/ha @ GS31	2.54^{bc}	9.6^{c}	1.1^{b}	78.1
80 kg N/ha @ GS31	3.14^{a}	10.7^{d}	0.6^{a}	80.7
100 kg N/ha @ GS31	2.99^{ab}	11.8^{e}	0.7^{ab}	80.5
200 kg N/ha @ GS31	2.98^{ab}	13.2^{f}	0.8^{ab}	79.9
Chicken litter 2.5 t/ha	2.52^{bc}	8.6^{ab}	1.2^{b}	80.3
Chicken litter with Bio Char 2.5 t/ha	2.49^{bc}	8.3^{ab}	0.9^{b}	80.1
Bio Char 100 kg/ha	2.33^{c}	7.8^{a}	1.0^{b}	80.2
LSD ($P \leq 0.05$)	0.51	1.0	0.3	NS

Summary

The results from 2018 indicate using lower N fertiliser rates was the best use of your fertiliser dollar in a dry season. Decisions on nitrogen application rates and timing are made by taking into account current available soil nitrogen, target yield, seasonal climatic forecasts, grain prices and fertiliser costs. Developing your own nitrogen budget is a good way to make decisions on your up-front and in-season nitrogen rates. Seasonal climatic forecasts and Yield Prophet® can more accurately determine potential yield and therefore assist in decisions on nitrogen application rates and timing.

Subsoil amelioration – four years on

Stuart Sherriff and Sam Trengove, Trengove Consulting

Key Findings

- The application of high rates of chicken litter or synthetic fertiliser to the surface or subsoil (in 2015) did not increase grain yields in 2018 above the untreated controls.
- At the Hill River sites, the long-term cumulative grain yields over the four years were higher in response to the application of chicken litter or synthetic fertiliser amendments in 2015. This was mostly due to high wheat yields in 2016.
- Across seven trials in the Mid-North and Upper Yorke Peninsula there have been inconsistent yield responses from subsoil amelioration. The impact of season and crop type has also had a large effect on yield response.

Why do the trial?

Subsoil constraints are known to have a large impact on grain yields in the Mid-North of SA. Trials in other regions including south western Vic have reported large yield responses (up to 60% yield increase in 1st year) from treatments of deep ripping and deep placement of high rates (up to 20 t/ha) of chicken litter. The grain yield response is thought to be coming from increasing the plant available water holding capacity of these soils by improving the structure of the subsoil. Although the cost associated with implementing these treatments is high, with these reported yield gains it is possible to pay for the treatments in the first season.

How was it done?

Seven randomised complete block design trials with three replicates of the same eight treatments (Table 1) were established in March 2015. The trials were located in three different geographic areas including two near Clare at Hill River, two at Hart and three at Bute. At each location the trials were located on different soil types which are described below.

Table 1. Treatment list for the 7 subsoil manuring sites established in 2015.

Treatment	Nutrition	Ripping	Placement
1	Nil	No	Nil
2	Nil	Yes	Nil
3	20 t/ha chicken litter	No	Surface
4	20 t/ha chicken litter	Yes	Surface
5	20 t/ha chicken litter	Yes	Subsoil
6	3 t/ha synthetic fertiliser	No	Surface
7	3 t/ha synthetic fertiliser	Yes	Surface
8	3 t/ha synthetic fertiliser	Yes	Subsoil

Plot size	2.5 m x 12.0 m
Seeding date	Hill River: 18th April Hart: 30th May Bute: 2nd May
Main treatments applied in 2015	As per treatment list (Table 1)
2018 crop and annual fertiliser	Hill River: 1.9 kg/ha 45Y91, 100 kg/ha 28:13 kg/ha IBS + 2 t/ha chicken litter and 1 t/ha gypsum pre seeding + 80 kg/ha urea 2nd July + 100 kg/ha Urea 27th July
	Hart: 70 kg/ha Commander barley, 100 kg/ha DAP + 65 kg/ha Urea 25th July
	Bute Mid: 90 kg/ha Trojan wheat, 90 kg/ha DAP + 50 kg/ha Urea 19th July Bute SE: 90 kg/ha Trojan wheat, 80 kg/ha DAP Bute NW: 80 kg/ha Mulgara oats, 80 kg/ha DAP

Sites and soil types

Hart East	Calcareous gradational clay loam Subsoil constraint: High pH and moderate to high ESP below 30cm
Hart West	Calcareous loam Subsoil constraint: High pH, Boron and ESP below 30cm
Bute Northwest	Calcareous transitional cracking clay Subsoil constraint: High pH, Boron and ESP below 30cm
Bute Mid	Calcareous loam Subsoil constraint: High pH, Boron and ESP below 60cm
Bute Southeast	Grey cracking clay with high exchangeable sodium at depth Subsoil constraint: High pH, Boron and ESP below 30cm
Hill River East	Black cracking clay
Hill River West	Loam over red clay Subsoil constraint: Moderate ESP below 60cm and moderate Boron below 90cm

The initial treatments (Table 1) were established prior to sowing in 2015. Ripping and subsoil treatments were applied with a purpose built trial machine loaned from Victoria DPI. The machine is capable of ripping to a depth of 600mm and applying large volumes of product to a depth of 400 mm. Chicken litter was sourced from three separate chicken sheds for ease of freight, the average nutrient content is shown in Table 2. After the treatments were implemented the plots at all sites were levelled using an offset disc. Since 2015 only seed and district practice fertiliser rates have been applied to all plots.

In 2018 the Hart sites were sown with narrow points and press wheels on 250 mm spacing. The Bute sites were sown using a concord seeder on 300mm spacing with 150 mm sweep points and press wheels and at Hill River the sites were sown using parallelogram knifepoint and press wheel seeder on 250 mm spacing.

The rate of chicken litter (20 t/ha) used in these trials was based on the rate being used in south western Victoria where the large yield responses had been observed. To assess if responses to chicken litter were attributed directly to the nutrition in the chicken litter, the 3 t/ha synthetic fertiliser treatment was designed to replicate the level of nutrition that is found in an average analysis of 20 t/ha of chicken litter. This treatment was made up of 800 kg/ha mono ammonium phosphate (MAP), 704 kg/ha muriate of potash (MoP), 420 kg/ha sulphate of ammonia (SoA) and 1026 kg/ha urea.

Table 2. Average nutrient concentration from three chicken litter sources used in subsoil manuring trials established in 2015.

Nutrient		Nutrient concentration dry weight	Moisture content	Nutrient concentration fresh weight	Kg nutrient per tonne fresh weight
N	Nitrogen	3.8 %	8%	3.50 %	35.0
P	Phosphorus	1.72 %		1.58 %	15.8
K	Potassium	2.31 %		2.13 %	21.3
S	Sulfur	0.55 %		0.51 %	5.1
Zn	Zinc	0.46 g/kg	8%	0.42 g/kg	0.4
Mn	Manganese	0.51 g/kg		0.47 g/kg	0.5
Cu	Copper	0.13 g/kg		0.12 g/kg	0.1

Measurements in 2018 include grain yield and quality at the Hart and Hill River sites and grain yield and quality at the Bute Mid and NW sites and hay yield at the Bute SE site.

Results

Hill River sites

Canola grain yield at the East site (brown cracking clay) averaged 1.9 t/ha. There were no significant treatment effects.

At the West site (loam over red clay), treatment differences were only significant at the 10% level (Table 2) where there was an 8.5% reduction in grain yield as a result of deep ripping. There was no consistent effect of nutrition, either chicken litter or synthetic fertiliser, on grain yield.

Table 2. Canola grain yield and quality for Hill River West subsoil amelioration trial in 2018.

Treatment	Chicken litter (t/ha)	NPKS	Ripping	Grain yield (t/ha)	Oil (%)	Protein (%)
1	0	No	None	1.97	44.0	20.9
2	0	No	Deep rip	1.84	43.5	22.0
3	20	No	None	1.95	41.5	23.2
4	20	No	Deep rip	1.94	41.9	23.2
5	20	No	Deep rip & place	1.88	41.6	23.2
6	0	3t/ha combo	None	2.07	43.2	21.9
7	0	3t/ha combo	Deep rip	1.71	42.2	22.7
8	0	3t/ha combo	Deep rip & place	1.77	42.4	22.5
LSD (0.10)				0.20	1.5	1.3

Bute sites

In 2018 the Bute NW site was sown to Mulgara oats for a seed crop and the Mid and SE sites were sown to Trojan wheat. Due to frost damage the SE site was cut for hay.

In-season NDVI of the Bute NW site (September) showed a reduction in plots that were deep ripped in 2015, excluding plots treated with chicken litter on the surface. This trend continued to grain yield where all plots that were ripped were lower yielding. Plot yields of treatments applied to the surface or the subsoil were equal.

The Bute Mid site was the highest yielding trial with grain yields ranging from 3.67 to 3.93 t/ha. Green seeker NDVI indicated that there was a significant nutrition response, with the highest values coming from the chicken litter treatments. In this trial ripping did not have an impact on grain yield. Placement of nutrition in the subsoil did result in lower yields than when applied to the surface. As expected, and for other sites, protein was elevated in the nutrition treatments, with chicken litter yield responses being slightly higher than those from the synthetic fertiliser.

Due to frost, the Bute SE site was cut for hay. NDVI in September indicated higher biomass in the chicken litter treatments when applied to the surface with a smaller response from the synthetic fertiliser. Hay yield responses were similar to the NDVI but were less significant.

Table 3. NDVI, Grain yield and quality for the Bute Northwest and Mid subsoil amelioration sites 2018.

			Bute NW Oat			Bute Mid Wheat		
Nutrition	Ripping	Placement	NDVI 5th Sept	Grain yield (t/ha)	Protein (%)	NDVI 5th Sept	Grain yield (t/ha)	Protein (%)
Nil	None	Nil	0.87	2.16	14.2	0.76	3.77	11.5
Nil	Yes	Nil	0.84	1.43	14.4	0.76	3.77	12.2
20 t/ha chic. lit.	None	Nil	0.87	1.66	15.1	0.84	3.87	14.5
20 t/ha chic. lit.	Yes	Surface	0.87	1.17	15.0	0.81	3.90	14.4
20 t/ha chic. lit.	Yes	Subsoil	0.86	1.15	15.3	0.80	3.67	13.9
3 t/ha syn. fert.	None	Nil	0.87	2.03	14.5	0.80	3.93	13.7
3 t/ha syn. fert.	Yes	Surface	0.85	1.45	15.0	0.79	3.77	13.9
3 t/ha syn. fert.	Yes	Subsoil	0.85	1.21	14.9	0.79	3.70	14.2
LSD (0.05)			*0.02*	*0.36*	*0.5*	*0.02*	*0.16*	*0.6*

Table 4. Greenseeker NDVI and hay yield for the Bute south east subsoil amelioration site 2018.

			Bute SE Wheat hay	
Nutrition	Ripping	Placement	NDVI 4th Sept	Hay yield (t/ha)
Nil	None	Nil	0.57	3.4
Nil	Yes	Nil	0.50	3.0
20 t/ha chic. lit.	None	Nil	0.63	3.6
20 t/ha chic. lit.	Yes	Surface	0.60	3.7
20 t/ha chic. lit.	Yes	Subsoil	0.53	3.2
3 t/ha syn. fert.	None	Nil	0.61	3.4
3 t/ha syn. fert.	Yes	Surface	0.56	3.5
3 t/ha syn. fert.	Yes	Subsoil	0.54	3.3
LSD (0.05)			*0.05*	*0.5*

Hart Sites

At the Hart West site, the application of 20 t/ha chicken litter (applied in 2015) resulted in a 34% reduction in barley grain yield when it was applied to the surface (Table 5). When placed in the subsoil the yield reduction was smaller. The synthetic fertiliser applied at the same time did not reduce grain yields. Although protein responses were only significant at the 10% level there is a trend showing plots treated with some form of nutrition had elevated protein. As per the grain yield, retention was reduced when chicken litter was applied to the surface and screenings were elevated. Ripping had little effect on the grain yield or quality at this site.

At the Hart East site, grain yields were lower, averaging 0.54 t/ha, potentially due to the effects of wide spread frost in the region given its lower elevation. However, there were similar levels of yield reduction (45%) when the chicken litter was applied to the surface. As expected, protein was elevated as a result of application of either chicken litter or synthetic fertiliser. Test weight was significantly reduced with the application of chicken litter to the surface. Grain size was generally reduced by application of either amendment.

Table 5. Grain yield and quality for the Hart subsoil amelioration sites 2018.

			Hart West				Hart East				
Nutrition	Ripping	Placement	Grain yield (t/ha)	Protein (%)	Retention (%)	Screenings (%)	Grain yield (t/ha)	Protein (%)	TW (kg/hL)	Retention (%)	Screenings (%)
Nil	None	Nil	1.31	16.7	85.7	1.5	0.83	18.7	62.9	79.0	6.1
Nil	Yes	Nil	1.12	18.2	82.9	2.0	0.75	19.7	61.9	67.2	9.1
20 t/ha chic. lit.	None	Nil	0.86	20.6	76.0	3.0	0.46	20.9	59.4	54.2	13.8
20 t/ha chic. lit.	Yes	Surface	0.76	19.9	74.1	3.3	0.30	22.4	59.4	44.6	17.2
20 t/ha chic. lit.	Yes	Subsoil	1.07	19.3	83.2	1.9	0.55	21.2	62.5	55.4	11.2
3 t/ha syn. fert.	None	Nil	1.08	19.3	83.6	2.0	0.60	20.5	61.3	64.3	9.3
3 t/ha syn. fert.	Yes	Surface	0.98	19.5	82.2	2.3	0.44	21.6	61.8	49.9	12.2
3 t/ha syn. fert.	Yes	Subsoil	1.06	19.1	82.8	2.0	0.39	21.4	61.5	47.1	14.7
LSD (0.05)			*0.30*		*4.0*	*0.8*	*0.19*	*1.3*	*1.4*	*12.7*	*4.2*
LSD (0.10)				*0.20*							

Summary and discussion for 2018

Ripping effects were either not significant or detrimental to yields at all sites. At Hill River there was little impact from the application of either chicken litter or synthetic fertiliser and ripping reduced yield at one site. At the Bute sites, there was a reduction in hay and grain yield at two of three sites as a result of ripping. Hart sites had a greater negative response from chicken litter than the synthetic fertiliser and ripping also resulted in lower yields. These results suggest that the effects of the synthetic fertiliser are diminishing in comparison to the chicken litter. This indicates a slower release and longer lasting effect from the chicken litter, albeit a negative effect in 2018.

Cumulative responses over four years

Given the significant investment in treatments of this nature, it is important to look at the long-term responses from soil amelioration. Figures 1 – 3 show cumulative grain yields for the seven sites from 2015 until 2018. These graphs show that the nutrition response at the Hill River sites in the high yielding season of 2016 caused the main differences in cumulative yield. At these two sites there has been little or no response to ripping or the placement position of the amendment. At other sites (Hart and Bute) most of the responses to ripping or the addition of either amendment have been insignificant or negative when compared to the nil treatment (T1).

Chicken litter effects on lentils

Lentil grain yields at Hart in 2016 and Bute in 2017 were reduced by an average of 29% and 23% respectively in response to chicken litter applied to the surface (Figure 4). This reduction was initially thought to be from high biomass production, resulting in higher levels of disease. However, observations throughout the growing season at Bute indicated similar disease levels throughout all treatments. It is not clear why the synthetic fertiliser applied to the surface did not have the same negative impact as chicken litter.

Deep ripping effects

Although generally not significant over the four years, the response to deep ripping alone was slightly negative at all but the Hill River East site. The large yield reductions in 2015 of up to 72% were a result of poor establishment due to the cloddy seed bed in the first year. However in subsequent seasons, crop establishment was good.

Chicken litter placement effects

Deep placement of chicken litter improved yields at Hart in the dry years of 2015 and 2018 (Figure 6). The deep placement delayed crop access to the amendment and delayed crop response, effectively reducing the canopy size compared to surface placement. This delayed response and interaction with reduced early soil moisture use is thought to explain the response to deep placement. Deep placement of chicken litter also improved yields of lentils at Hart (2016) and Bute (2017) compared with surface application. This was due to surface application negatively effecting lentil yields rather than subsoil placement being positive. At the Hill River sites in 2016, when there was the greatest response to the application of an amendment, the depth of placement was not important (Figure 6). This indicates that the grain yield responses achieved at this site were likely due to increased nutrition and not amelioration of the subsoil.

Chicken litter vs. synthetic fertiliser

Grain and hay yields from synthetic fertiliser treatments applied to the surface have generally been equal or greater than that of the plots treated with chicken litter (Figure 7). The greatest difference in grain yields between these treatments was produced at the Hart West site and was 1.0 t/ha or 40%. This occurred in the lentil phase and can be attributed to yield reductions from chicken litter rather than yield increases from synthetic feritilser. A similar effect occurred at the Bute sites in 2017. Other increases in grain yield from synthetic fertiliser compared to chicken litter may be attributed to; poorer emergence at Hart in 2015 as a result of toxic levels of fertiliser being applied to the surface resulting in reduced canopy and retained soil moisture for the end of the season. Because of the low yields at the Hart sites in 2018, the large relative differences are only 0.23 and 0.24 t/ha for the East and West sites respectively.

Figure 7 is a photograph of a soil pit at the Hart West site showing how the 20 t/ha chicken litter appears to have changed little from when it was placed there in 2015. This also indicates that there has been little amelioration of the subsoil. Soil pits at other sites have not been excavated.

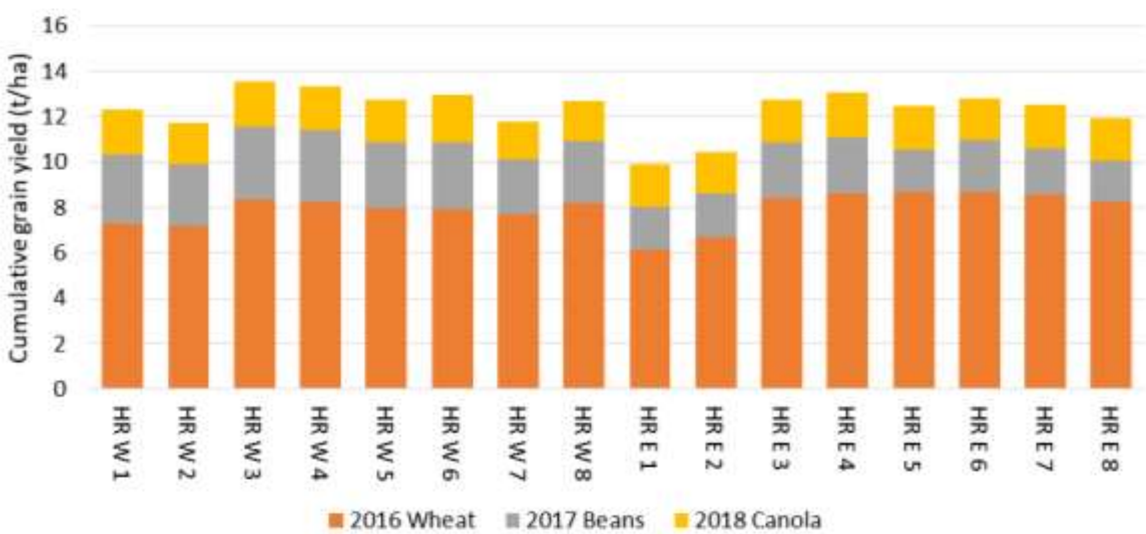

Figure 1. Cumulative grain yield (t/ha) for the Hill River subsoil amelioration sites from 2016 to 2018. LSD (0.05) for Hill River West (HR W) = 0.9 and Hill River East (HR E) = 0.9. For treatments see Table 1.

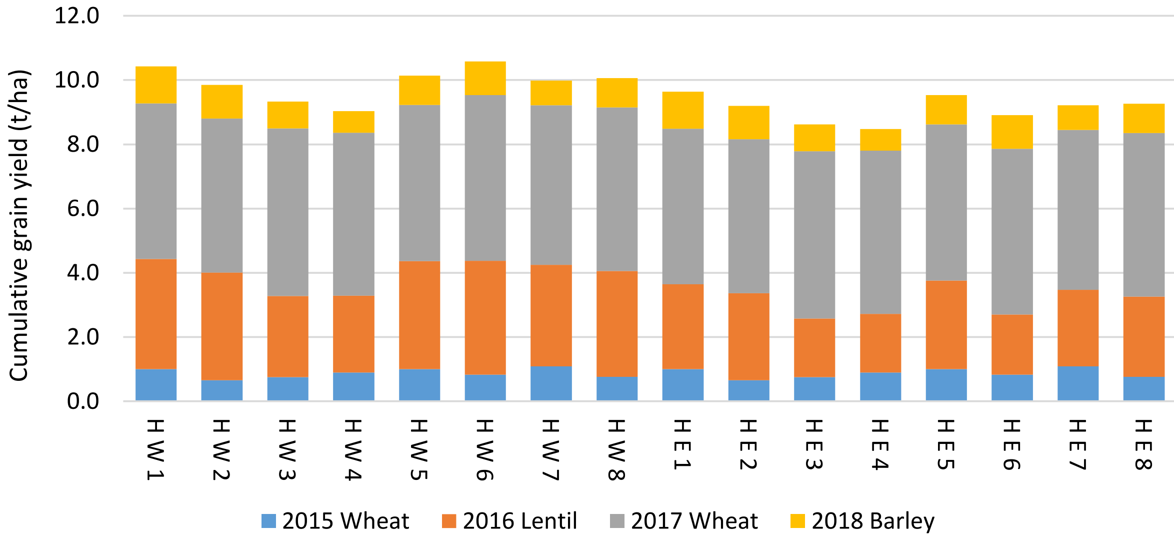

Figure 2. Cumulative grain yield (t/ha) for the Hart subsoil amelioration sites from 2015 to 2018. LSD (0.05) for Hart West (H W) = 0.9 and Hart East (H E) = 0.7. For treatments see Table 1.

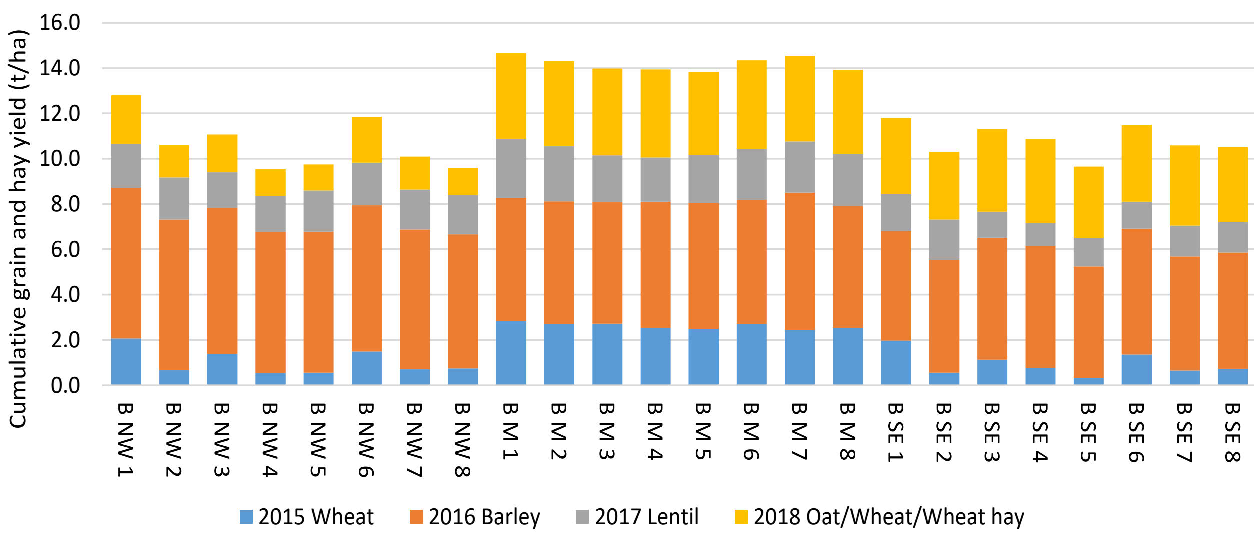

Figure 3. Cumulative grain and hay yield (t/ha) for the Bute subsoil amelioration sites from 2015 to 2018. In 2018 NW was oats, Mid was wheat and SE was wheat hay. LSD (0.05) for Bute north west (B NW) = 0.7, LSD (0.10) for Bute mid (B M) = 0.7 and Bute south east (B SE) = 0.7. For treatments see Table 1.

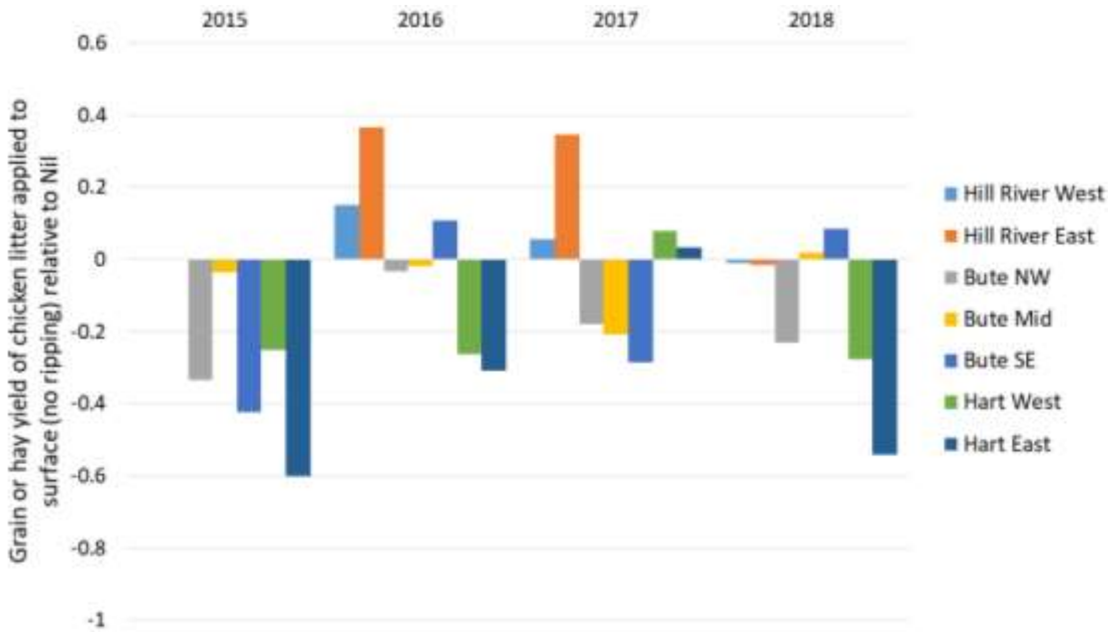

Figure 4. Grain and hay yield response of surface applied chicken litter (20 t/ha) relative to the nil treatment for subsoil manuring sites 2015 – 2018.

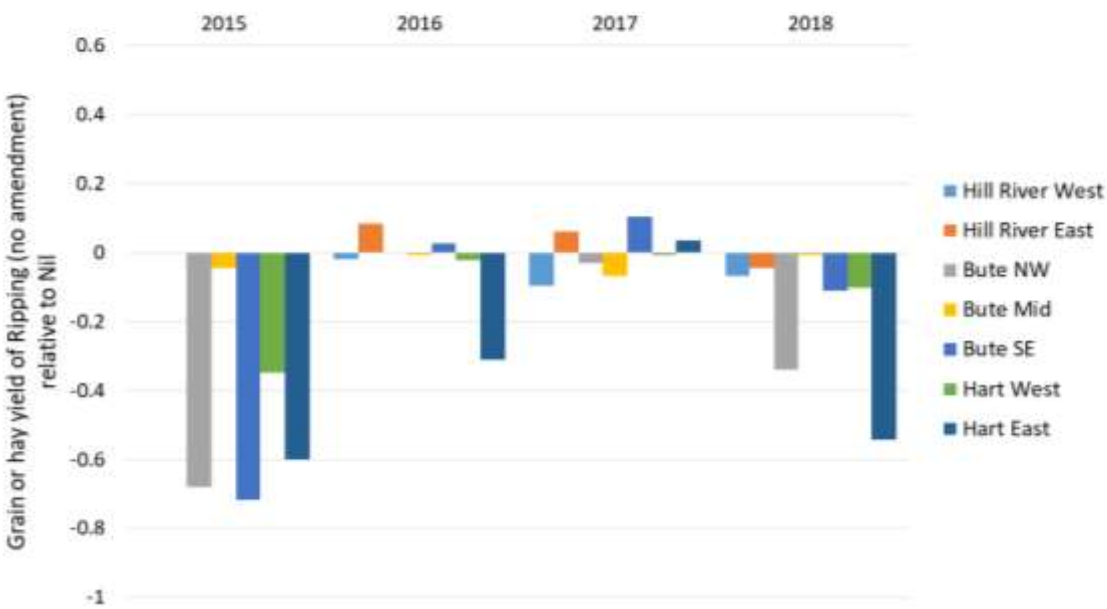

Figure 5. Grain and hay yield response to ripping in the absence of an ameliorant relative to the nil treatment for subsoil manuring sites 2015 – 2018.

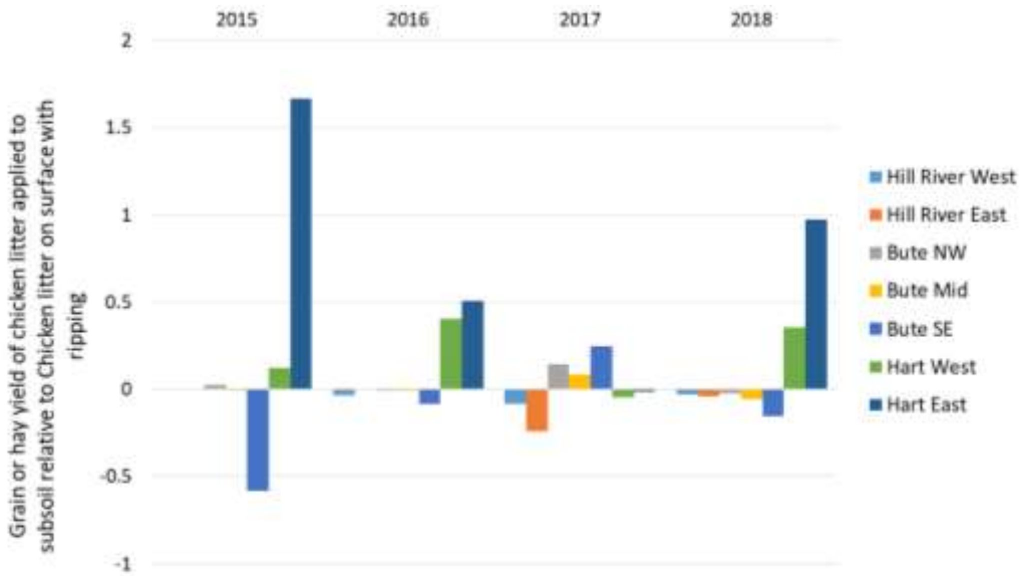

Figure 6. Grain and hay yield response to placing 20 t/ha of chicken litter in the subsoil relative to the placing 20 t/ha chicken litter on the surface for subsoil manuring sites 2015 – 2018.

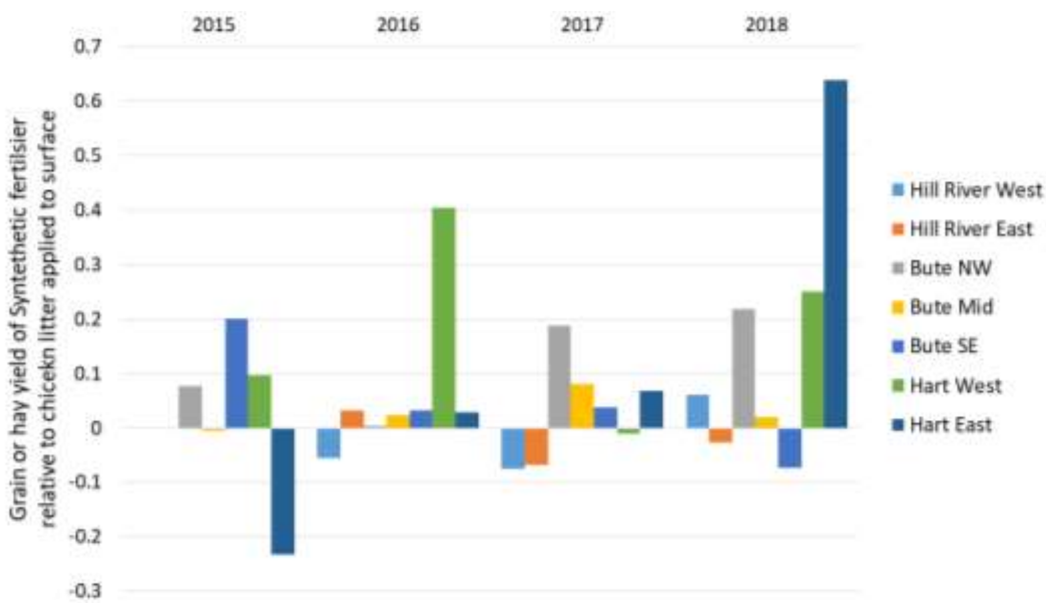

Figure 7. Grain and hay yield response of 3 t/ha of synthetic fertiliser applied to the surface relative to applying 20 t/ha of chicken litter to the surface, with no ripping, for subsoil manuring sites 2015 – 2018.

Figure 7. Subsoil applied chicken litter (20 t/ha) at the Hart West site. Photo taken on October 2018, after three years and seven months in the soil.

Summary / implications

Subsoil amelioration using the method of ripping chicken litter or synthetic fertiliser into the subsoil has not led to increased grain yields at any of the seven sites set up in 2015. In most cases the ripping process required to place the amendment into the subsoil caused significant soil disturbance and resulted in reduced grain yields. The amendment itself applied either to the surface or at depth did increase yields significantly in the high yielding season of 2016 at the Hill River sites, but other than that most responses have been neutral or negative. Given these results undertaking these treatments on these soil types on a paddock scale is not recommended.

Acknowledgements

Trial co-operators Bill Trengove, Matt Dare and Craig Jaeschke, Vic DPI for loan of the subsoil manuring machine, Jim Maitland for providing chicken litter at the Hart site and Australian Growers Direct for providing facilities for grain quality analysis.

Does temperature affect variety and N decisions?

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Key Findings

- Nitrogen fertiliser decisions need to take into account variety and sowing date.
- Yield losses may reach up to 0.67 t/ha per °C during the critical period (20 days before to 10 days after flowering) for yield determination.

Why do the trial?

Heat stress can reduce grain yield of wheat in Australia by 10-15%. Variety selection, nitrogen (N) rate, and sowing time are key factors determining the attainable grain yield. Nitrogen management remains one of the most important and risky decisions for farmers. Shifts in sowing times and variety selection modify the environmental conditions during the critical period for yield determination (20 days before and 10 days after flowering). For instance, while early sowing may improve the yield of some late maturing varieties, it could also increase the risk of frost for early maturing varieties sown too early. To tailor nitrogen input to sowing time and variety, we need an understanding of the interactions between N, temperature and crop phenology. Therefore, four experiments were carried out to develop guidelines to manage the 3-way interaction between N, variety and sowing date.

How was it done?

Plots size	1.75 m x 6 m and 2 x 15 m	**Fertiliser**
Seeding date	13/5/17 and 14/5/18	Urea (46:0)
	26/5/17 and 27/5/18	@ 0 kg N/ha, 2-4 leaf & first node
	9/6/17 and 24/6/18	@ 50 kg/N ha, 2-4 leaf & first node
	23/6/17 and 10/7/18	@ 100 kg N/ha, 2-4 leaf & first node
		@ 200 kg N/ha, 2-4 leaf & first node

Field trials were carried out at Turretfield and Hart in 2017 and at Roseworthy and Mintaro in 2018. In each location, trials combined four sowing times, six wheat varieties, and four N rates. Varieties were selected based on N requirements and phenology (Table 1). Nitrogen treatments consisted of unfertilised controls, and three fertiliser rates (50, 100 and 200 kg N/ha) applied as urea. Nitrogen application was split in 50% at early tillering and 50% just before stem elongation.

Additionally, an experiment was established at Hart 2017 and Roseworthy 2018 to look at temperature and other factors confounded in sowing time trials. Two temperature regimes were compared: unheated controls and crops heated with open-top passive heating cubes (1.5 m wide, 1.5 m length and 1.5 height) (Photo 1). These thermal regimes were established in crops of Mace and Spitfire, with two N rates (0 and 100 kg N/ha). The timing of heating was from booting to 10 days after flowering and from 10 days after flowering until maturity.

Table 1. Wheat varieties trialed.

Variety	Maturity type
Axe (AGT)	Early flowering and very early maturity variety suited to southern Australia
Cobra (LongReach)	High yielding early-mid maturity variety suited to high yielding areas of Southern Australia
Mace (AGT)	Early to mid-season maturity and has been the leading wheat variety in both WA and SA in recent seasons
Scout (LongReach)	Mid maturity variety, derived from Yitpi
Spitfire (LongReach)	Is an early mid maturing variety with high grain size and consistently high grain protein
Trojan (LongReach)	Mid-late maturing variety

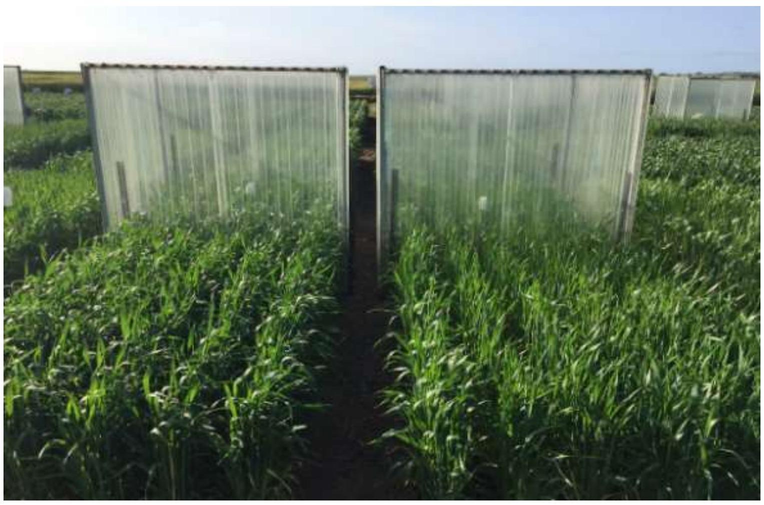


Photo 1. Open-top passive heating system before flowering (above top) and during grain filling (above bottom).

For the pooled data we estimated a maximum yield with a method similar to French and Schultz. An upper limit of yield (95 percentile) was calculated as a function of the mean (average) temperature during the critical period (20 days before and 10 days after anthesis). For each treatment, a yield gap was obtained as the difference between actual yield and yield at the boundary.

Results and discussion

Grain yields ranged between 5.96 t/ha (Mace, 200 kg N/ha sown at Hart on 13 May 2017) and 0.13 t/ha (Cobra, 200 kg N/ha at early sowing at Mintaro date 2018). Across two seasons, yields averaged 3.5 t/ha in 2017 and 1.54 t/ha in 2018. The variation in grain yield was mainly due to rainfall, N availability and frost events.

The relationship between grain yield and the mean temperatures during critical period (20 days before and 10 days after flowering) had an upper limit (boundary) function indicating a maximum potential yield loss of 0.67 t/ha per ^{o}C (Figure 1a). In all locations, delaying sowing (from May into June) decreased yield with the exception of Mintaro, where recurrent frost favoured later sowings (Figure 1b).

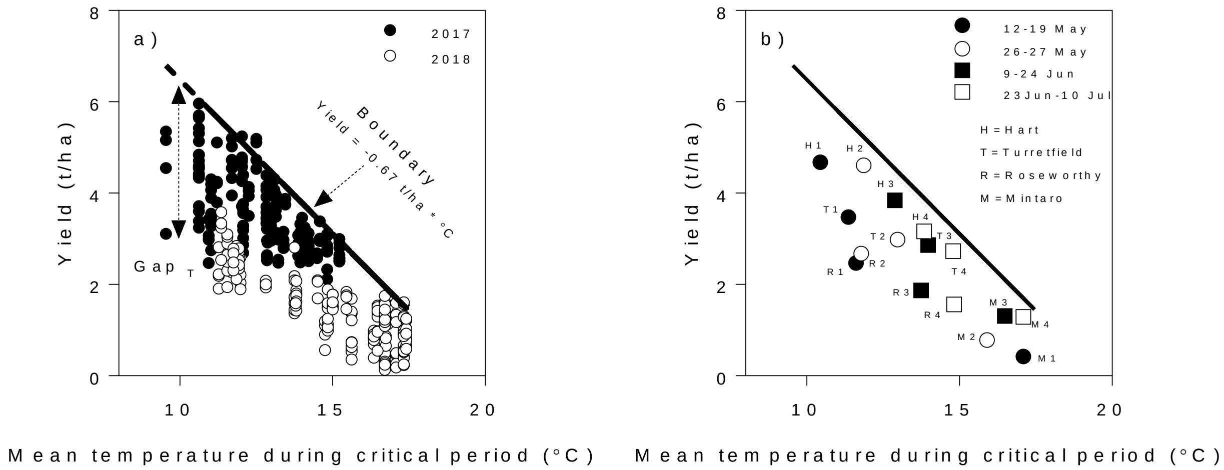


Figure 1. (a) Boundary line for the relationship between grain yield and mean temperature during the critical period for all treatments in 2017 (closed symbols) and 2018 (open symbols). The line is an upper limit with a slope of 0.67 t/ha per ^{o}C. (b) Average yield across varieties and N treatments for each sowing time and location combination as a function of mean temperature during critical period.

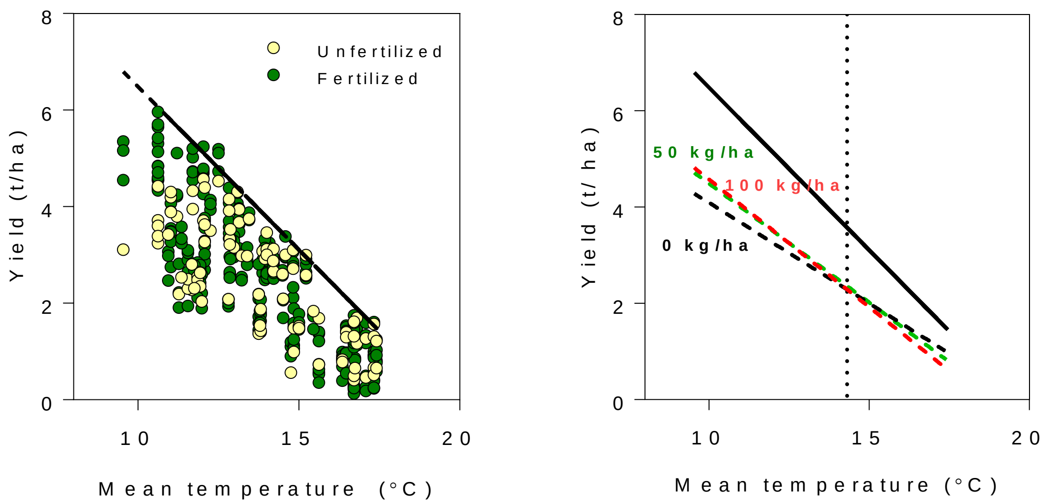


Figure 2. Grain yield as a function of mean temperature during critical period for fertilised (green) and unfertilised (yellow) plots (left panel) and different treatments (right panel) of 0 kg N/ha (black), 50 kg N/ha (green) and 100 kg N/ha (red). Dashed lines indicate the average regression line for each treatment, continuous black line indicates the boundary function. Vertical dotted line indicates break temperature point between treatments.

The response of grain yield to N depended mainly on location (N availability, rainfall), time of sowing and their interaction. In general, N had a positive effect on grain yield across locations and varieties. However, there was interaction with the mean temperature during critical period that is important (Figure 2). Advantages of N fertilised treatments disappeared when mean temperatures during critical period increase over 14.3 °C.

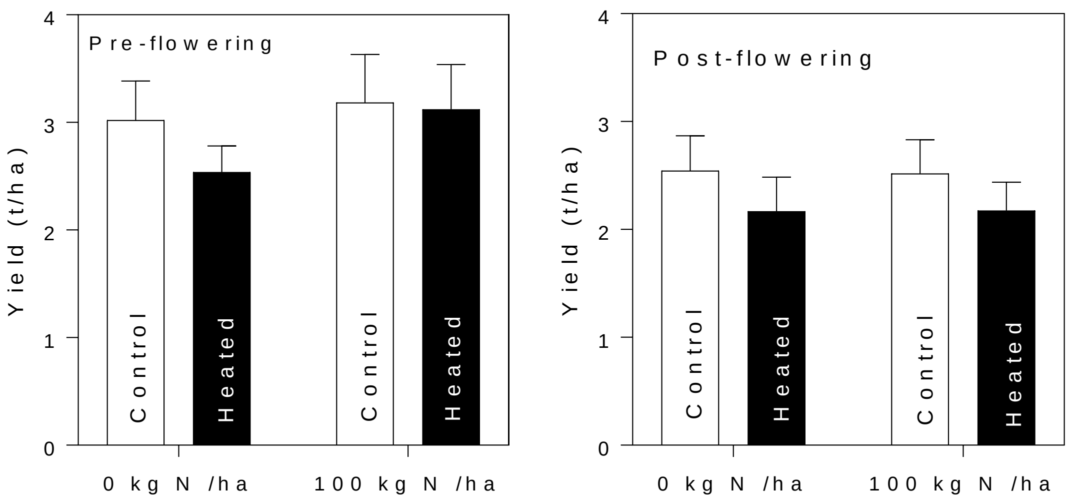


Figure 3. Average of two years of experiments for the main effect of temperature and time of heating (left panel = pre-flowering, right panel = post-flowering) on grain yield for unfertilised and fertilised crops. Whiskers indicate standard error of the mean for each treatment.

Results of the heating cubes were in line with the sowing date trials indicating a positive effect of N to maintain grain yield, especially when higher temperature occurs during the period of grain number determination (pre-flowering treatment) (Figure 3). Heating cubes reduced the yield of crops in both periods of heating (before and after flowering) (Figure 3). Fertilising crops with 100 kg N/ha reduced the impact of higher temperatures mainly through sustaining the grain number per square meter.

Summary / implications

Mid-May sowing increased yield potential, i.e. yield in the absence of stress. Delaying sowing reduced yield potential up to 0.67 t/ha per °C of mean temperature during critical period. Adequate N nutrition and longer-season spring varieties reduced the yield gaps in relation to temperature. Responses to N become more erratic when temperatures during the critical period increase above ~14.5 °C. Strategic N management (50-100 kg N/ha) may help to mitigate the effect of higher temperatures on grain number and yield.

Acknowledgements

Funding for the establishment, maintenance, and analysis of field trials has been provided by the GRDC-SARDI (DAS00166). We especially thank the Hart Field-Site Group and John Faulkner and his family for their support to our field research, Longreach Seeds and AGT for the provision of seeds for carry out the experiment. We also thanks to students (Bethany Sleep, Alvaro Sanchez Virosta and Anabel O'Dea) and casuals (Jose, Han, Martin, Gaston, Tanja, Habtamu) for their work in laboratory and field activities.

Long term comparison of seeding systems

Sarah Noack, Hart Field-Site Group

Key findings

- Below average rainfall resulted in field pea grain yields of 0.7 to 1.0 t/ha.
- There were small differences among seeder types in grain yields but no effect of historic nitrogen application.
- Available soil nitrogen pre-seeding was similar across all treatments after high yields and good protein levels in the previous season and low summer rainfall for mineralisation.

Why do the trial?

The Hart cropping systems trial is unique; running since 2000 it provides SA grain growers with information on the long-term effects of cropping systems (a combination of seeders, tillage and stubble management) and nitrogen fertiliser regime. There continues to be industry interest in disc seeders due to their ability to retain heavy stubble, minimise soil disturbance, increased seeding speed and seed depth uniformity. To date the trial has shown no one cropping system or nutrition regime is consistently higher in grain yield, quality or gross margin.

The trial aims to compare the performance of three seeding systems and two nitrogen (N) strategies. This is a rotation trial (Figure 1) to assess the long-term effects of seeding systems and higher fertiliser input systems on soil fertility, crop growth and grain yield and quality.

How was it done?

Plot size	35 m x 13 m	**Fertiliser**	DAP (18:20) at seeding @ 75 kg/ha
Seeding date	1st June – No-till 6th June – Disc 14th June – Strategic	**Medium nutrition** **High nutrition**	No extra fertiliser applied No extra fertiliser applied
Variety	PBA Wharton field pea @ 100 kg/ha		

The trial was a randomised complete block design with three replicates, containing three tillage/seeding treatments and two N treatments. In addition to this in 2017 all disc treatments were harvested using a stripper front (average stubble height 65 cm). Both the no-till and strategic stubble height were harvested at 24 cm stubble height.

The disc, strategic and no-till treatments were sown using local growers Tom Robinson, Michael Jaeschke and Matt Dare's seeding equipment, respectively.

2000	2001	2002	2003	2004	2005	2006	2007
Sloop barley	ATR-Hyden canola TT	Janz wheat	Yitpi wheat	Sloop barley	Kaspa peas	Kalka durum	Janz wheat

2008	2009	2010	2011	2012	2013	2014	2015
Janz wheat	Flagship barley	Clearfield canola	Correll wheat	Gunyah peas	Cobra wheat	Commander barley	44Y89 (CL) canola

2016	2017	2018
Scepter wheat	Scepter wheat	Wharton field pea

Figure 1. Crop history of the long-term cropping systems trial at Hart 2000 – 2018.

Seeding treatments:

Disc – sown into standing stripper front stubble with John Deere 1890 single discs at 152 mm (6”) row spacing, closer wheels and press wheels.

Strategic – worked up pre-seeding, sown with 100 mm (4”) wide points at 200 mm (8”) row spacing with finger harrows.

No-till – sown into standing stubble in one pass with a Flexicoil 5000 drill, 16 mm knife points with 254 mm (9”) row spacing and press wheels.

Nutrition treatments:

Medium – no additional fertiliser applied this season.

High – no additional fertiliser applied this season.

All plots were assessed for soil available N (0-20, 20-40, 40-60 and 60-80 cm) on the 16th of April. Plant establishment was assessed by counting 4 x 1 m sections of row across each plot on 9th of July. All plots were assessed for grain yield at harvest (23rd November). All data was analysed using ANOVA in Genstat with seeding date as a covariate.

Results and discussion

Soil available N was measured in autumn and ranged between 59 kg N/ha to 106 kg N/ha (Figure 2). The high nutrition treatment had not accumulated more N as in previous seasons, averaging 97 kg N/ha for the high and 78 kg N/ha for the medium treatment. The lack of difference can be explained by high wheat protein levels (6.7% protein in medium versus 10.8% protein in the high) in the high nutrition treatment in 2017 extracting more N from soil reserves. Low summer rainfall would have also reduced soil nitrogen mineralisation and contributed to reduced soil available N pre-seeding.

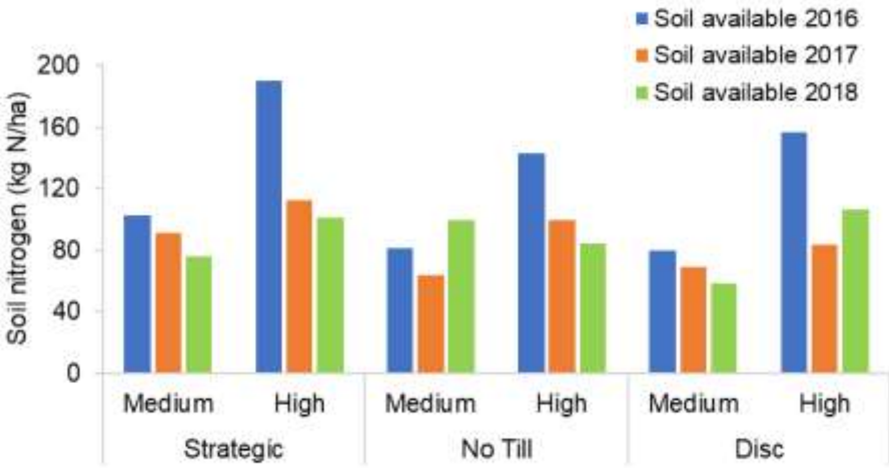


Figure 2. Soil available nitrogen (kg N/ha) pre-seeding for Hart long-term seeding systems trial from 2016 – 2018.

There were significant differences in plant establishment among the seeders. In general, the no-till treatment had the highest plant establishment at 14 plants/m^2 compared to disc and strategic however, they were only reduced by 5 and 3 plants/m^2, respectively (data not shown). The images below capture these differences, with more uniform plant establishment in the no-till compared to the strategic (prickle chained post seeding) and disc treatments (tall stripper front stubble).

Figure 3. (Left to right) PBA Wharton field pea sown in the strategic, no-till and disc treatment taken on 27th August, 2018.

Field pea grains yields were low across the trial, ranging from 0.7 to 1.0 t/ha (Table 1). The dry season combined with later seeding dates (early-mid June) resulted in below average yields. The no-till treatment provided the highest yield at 0.9 t/ha however, there was only 0.3 t/ha differences across all treatments.

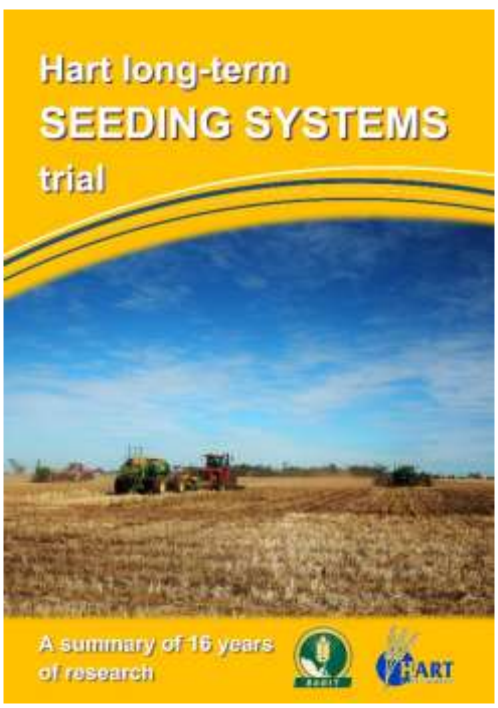
One of the main outcomes from this trial has been the lack of consistent performance in terms of grain yield from any one particular seeding system over the last 19 years. In the last five seasons (Table 1), four years have shown differences in grain yield among the seeding systems. In seasons where yield differences were observed, the no-till and disc alone or together outperformed the strategic treatment.

Table 1. Grain yield (t/ha) for all seeder and nutrition treatments for the past five seasons.

Seeder type	**Fertiliser strategy**	**2014 Barley**	**2015 Canola**	**2016 Wheat**	**2017 Wheat**	**2018 Field pea**
		grain yield t/ha				
Strategic	Medium	4.4	0.6	4.8	4.8	0.8
	High	3.9	0.6	5.9	5.9	0.7
No Till	Medium	4.7	0.6	4.2	4.2	0.9
	High	4.0	0.5	5.8	5.8	1.0
Disc	Medium	4.5	0.5	5.0	5.0	0.7
	High	4.0	0.5	5.9	5.9	0.7
LSD nutrition (P≤0.05)		ns	ns			ns
LSD seeder (P≤0.05)		0.2	ns			0.2
LSD seeder x nutrition (P≤0.05)		ns	ns	0.3	0.3	ns

Acknowledgements

The HFSG thank the South Australians Grains Industry Trust (SAGIT) for providing funding to support this research (H116). They also thank all the growers and SARDI Clare who assisted with trial seeding, spraying and harvesting.



Optimising plant establishment – seeder comparison: precision planter & conventional seeder in canola and lentils

Emma Pearse[1], Sarah Noack[1], Glenn McDonald[2] and Stefan Schmitt[3]
[1]Hart Field-Site Group, [2]University of Adelaide, [3]Ag Consulting Co

Key findings

- Lower plant establishment numbers were observed from the precision planter compared to the conventional seeder. However, this did not result in a yield penalty.
- In general, the precision planter was able to reduce the variation in distance between plants compared to the conventional seeder.
- The precision planter was able to maintain, and in some cases improve, grain yields in lentils and canola.

Why do the trial?

Currently there is little information on plant establishment from new and existing seeder types in winter crops across Australia. Crop patchiness and variability is commonly observed in paddocks and can be attributed to both seeding conditions (e.g. soil temperature, moisture, pest pressure) and seeder setup (e.g. seeding depth).

Emerging plants compete against each other for resources to grow. The competitiveness of a plant is determined by a number of factors including seed vigour, proximity to neighbouring seeds/plants and the speed to germination and full emergence. Uniformity in seed placement could be beneficial to crop emergence and yield by reducing competitiveness between plants whilst retaining high plant densities and improving canopy architecture. This uniformity could be achieved by using a precision planter (seed singulation) at seeding time.

There is limited research into the use of precision planters in Australian winter crops, such as wheat, canola, lentils and faba beans. Benefits of using a precision planter could include seed input/cost reductions and increased yield.

This research has been funded by GRDC and will span over four years, beginning in 2018. It aims to investigate our current seeding systems and review if precision planters have a fit in the southern and western winter grain growing regions of Australia. Before recommendations can be made we need to understand the variation in crop establishment across various seeder types, and if this variation has an impact on grain yield and quality.

How was it done?

Plot size	1.37 m or 1.52 m x 12 m	**Fertiliser**	DAP @ 60 kg/ha at seeding
Row spacing	Narrow = 22.9 cm (9”) Wide = 30.5 cm (12”)		UAN (42:0) @ 95 L/ha on 5th July – canola only UAN (42:0) @ 55 L/ha on 2nd August - canola only
Seeding date	10th May 2018 (17th May for wide precision planter)		

Two crop types we evaluated; 44Y89 (CL) canola and PBA Hurricane XT lentil. Each trial was a split-plot randomised design, blocked by seeder type (conventional tyne seeder and a disc precision planter) and row spacing (narrow 9" (22.9 cm) and wide 12" (30.5 cm)). The two trials were sown at six different seeding rates outlined in Table 1. The trial was sown on the 10th May 2018, except for the precision planter wide treatment which was sown on the 17th May 2018 due to rainfall and technical issues.

All plots were assessed for plant establishment number, distance between plants, seedling depth, biomass and harvest index during the season. Grain yield and quality was assessed at harvest. Statistical analysis was performed on the data in Genstat using ANOVA.

Table 1. Seeding rate, target plant densities and actual plant number measured in the field (averaged across seeders and row spacing).

	Canola			Lentils		
Plant density	Seeding rate kg/ha	Target plants/m^2	Actual plant number/m^2	Seeding rate kg/ha	Target plants/m^2	Actual plant number/m^2
1	0.7	15	14	14	40	36
2	1.1	25	18	20	60	48
3	1.6	35	24	27	80	78
4	2.0	45	38	34	100	95
5	2.5	55	43	40	120	116
6	2.9	65	47	47	140	124

Canola plant establishment

Results and discussion

Plant establishment was greater for canola sown with a conventional seeder compared to the precision planter (Figure 1). Across all seeding rates, the conventional seeder averaged 35 plants/m^2 compared to 26 plants/m^2 in the precision planter. The precision planter used in this trial was a double disc opener setup. At seeding time, the disc struggled to penetrate into clay-loam soil, and this may have contributed to the lower plant establishment. A number of skips (missed seeds) and multiples (more than one seed) were observed when emergence counts were measured. Plant establishment did not differ between the two row spacing treatments when sown with the conventional seeder (Figure 1).

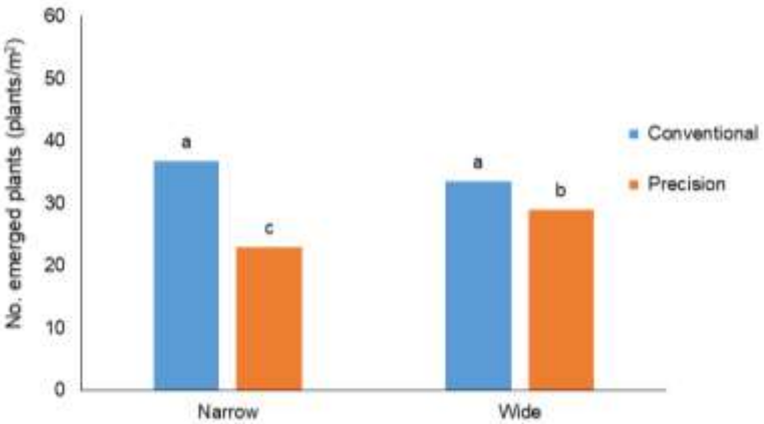


Figure 1. Average number of canola plants emerged (plants/m^2) in both the conventional seeder and precision planter at two different row spacing treatments (narrow – 9" and wide – 12"). (LSD=4 at P≤0.05).

Distance between plants

The distance between plants was greater in canola sown with the precision planter (17.3 cm) compared to the conventional seeder (13.8 cm). Although the distance between plants was greater for the precision planter, it was more consistent (Table 2). This is in contrast to the conventional seeder which often clumped three of four plants close together.

Table 2. The average distance between plants (cm) and variation (CV%) in both the conventional seeder and precision planter plots in the canola trial. (LSD= 1.75 at P≤0.05).

	Average (cm)	CV (%)
Conventional	13.8	108
Precision	17.3	88

Grain yield

There was no overall difference in canola grain yield between the two seeders averaging 1.39 t/ha (precision planter) and 1.33 t/ha (conventional). The narrower row spacing (9”) contained a small yield advantage over the wide (12”) row spacing (Table 3). This first year of data has shown the precision planter was able to maintain canola grain yield similar to the conventional seeder.

While there was no interaction between seeder type and plant density, grain yield did vary between plant densities (Table 3). A plant density of 38 plants/m^2 (equivalent to 2 kg/ha seeding rate) was required to produce the highest average grain yield at 1.44 t/ha. Reducing the plant establishment number below 38 plants/m^2 resulted in a yield penalty of up to 0.21 t/ha.

Table 3. Canola grain yield for plant establishment, seeder and row spacing treatments at Hart, 2018.

Average establishment (plants/m^2)	Precision		Conventional	
	Wide (12")		Narrow (9")	
14	1.12	1.22	1.32	1.26
18	1.21	1.29	1.50	1.09
24	1.29	1.09	1.54	1.41
38	1.34	1.09	1.56	1.50
43	1.36	1.36	1.56	1.49
47	1.32	1.32	1.57	1.57
LSD(P≤0.05) row spacing = 0.07; average establishment = 0.13				

Lentil plant establishment

Seeder type had a significant effect on lentil plant establishment. The conventional seeder resulted in higher plant establishment compared to the precision planter across three of the target densities (Figure 2). The conventional seeder had an average plant number of 91 plants/m^2, higher than 70 plants/m^2 from the precision planter. The precision planter did not achieve the target plant densities and in general established 20 plants/m^2 less than the target. Soil-seed contact and achieving good seeding depth was an issue for the precision planter at Hart and may have reduced the plant establishment. In 2019 the disc seeder will be used to sow both the precision planter and conventional seeder treatments to remove this difference in seeder setup.

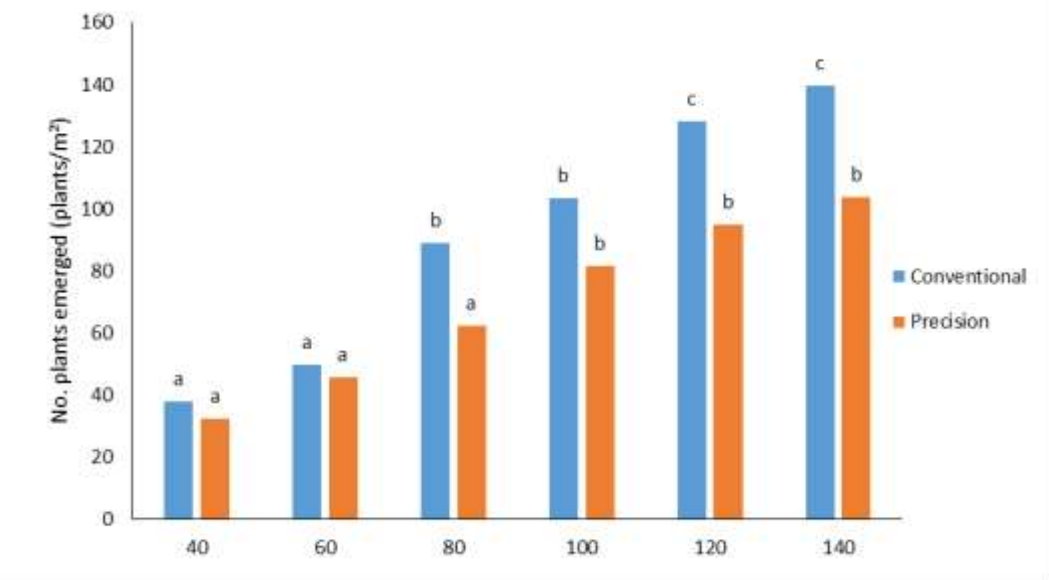


Figure 2. Average number of lentil plants emerged (plants/m^2) across the six different target densities in both the conventional seeder and the precision planter. (LSD=23.7 at P≤0.05).

The precision planter had a higher average distance between plants (6.9 cm) compared to the conventional seeder (Table 4). Similar to canola, the variation in the distance between plants was lower in the precision planter (71%) compared to the conventional seeder (Table 4). A lower variance indicates that, in this trial, the precision planter was able to better singulate lentil seeds to keep a consistent distance between. Photo 1. shows the difference in seed placement between the conventional seeder and the precision planter.

Table 4. The average distance between plants (cm) and variation (CV%) in both the conventional seeder and precision planter plots in the lentil trial. (LSD= 0.65 at P≤0.05).

	Average (cm)	CV (%)
Conventional	5.7	107
Precision	6.9	71

Photo 1. Hurricane lentils sown with a conventional seeder (left) and a precision planter (right). Both sown on narrow row spacing (9") and a target density of 100 plants/m^2.

Lentil grain yield was higher in precision planter plots compared to the conventional seeder (Figure 3). The precision planter averaged 1.4 t/ha, compared to 1.2 t/ha in the conventional seeder. Despite having reduced plant establishment number, there was no yield penalty in the precision planter.

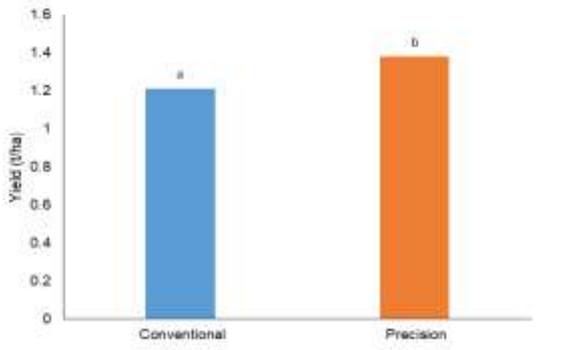


Figure 3. Average lentil yield (t/ha) in both the conventional seeder and precision planter. (LSD=0.1 at P≤0.05).

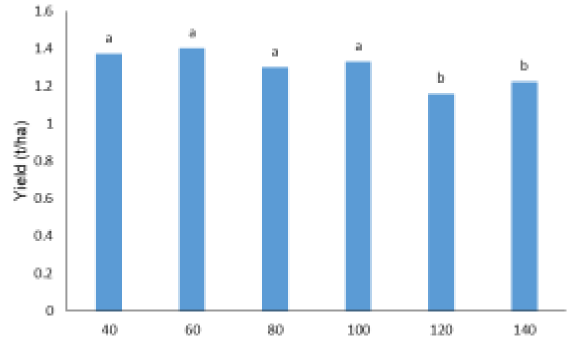


Figure 4. Combined average lentil yield across the six different target densities in both the conventional seeder and the precision planter. (LSD=0.14 at P≤0.05).

Interestingly lentil yields were higher at lower target planting densities. The average yield for plant densities 40 – 100 plants/m^2 ranged from 1.3-1.4 t/ha (Figure 4). Lentil varieties are recommended to be sown at 100 – 120 plants/m^2 (GRDC 2017) however, in this trial sowing at 40 – 100 plants/m^2 maintained the highest yields (Figure 8). With lower plant numbers will come lower competition for resources between the seedlings, reducing competition and potentially leading to increased plant growth and maintain high yields. It should be noted that this trial was managed under low weed and disease pressure.

Summary

In the first year of research we've found:

- Better plant establishment, in both canola and lentil trials, was achieved by sowing with the conventional seeder. In particular the precision planter failed to hit any of the lentil target plant densities due to difficulties with singulation and seed-soil contact.
- The precision planter was able to maintain, and in some cases improve grain yields in lentils and canola.
- Lentil grain yields were maintained at lower than recommended target seeding densities. It should be noted that the trial was managed under low weed and pest pressure and this may not be observed under all paddock conditions.
- In general, the precision planter was able to reduce the variation in the distance between plants compared to the conventional seeder.

Acknowledgements

The authors gratefully acknowledge GRDC for funding this project 'Optimising plant establishment, density and spacing's to maximise crop yield and profit in the southern and western regions' (9176134).

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Yield Prophet® performance in 2018

Sarah Noack, Hart Field-Site Group

Key findings

- Yield Prophet® closely predicted wheat grain yield for Mace towards the end of the season.
- Lack of rainfall during the season meant the difference between 20% and 80% of years was 1.0 t/ha in mid-September and had decreased to only 0.3 t/ha in early October.

Why do the trial?

Wheat growth models such as APSIM are highly valuable in their ability to predict wheat yield.

Yield Prophet® is an internet based service using the APSIM wheat prediction model. The model relies on accurate soil character information such as plant available water and soil nitrogen levels, as well as historical climate data and up to date local weather information to predict plant growth rates and final hay or grain yields.

This early prediction of grain yield potential means it can be used to directly influence crop input decisions. No other tool is currently available to growers, which can provide information of this accuracy at such a useful time of the season.

How was it done?

Seeding date	1st May 2018	**Fertiliser**	30 kg N/ha 1st May 20 kg N/ha 18th July
Variety	Mace wheat @ 180 plants per square metre		

Yield Prophet® simulations were run throughout the season to track the progress of wheat growth stages and changes in grain yield predictions.

20%, 50% and 80% levels of probability refer to the percentage of years where the corresponding yield estimate would have been met, according to the previous 100 years of rainfall data.

Results

At the first simulation on 27th June, Yield Prophet® predicted that Mace wheat sown on the 1st May would yield 3.7 t/ha in 50% of years (Figure 1). After well below average rainfall in June and July (Table 1), it is not surprising that this yield prediction reduced to 2.7 t/ha from mid-June until late August.

The Yield Prophet® simulation in mid-September decreased further to 2.2 t/ha. This was driven by below average rainfall for September (Table 1). By the start of October, the 20%, 50% and 80% of year's prediction were closely aligned between 1.8 – 2.1 t/ha. The actual grain yield for Mace sown in mid-May was 2.0 t/ha in the Hart wheat variety trial. Yield Prophet® closely predicted wheat grain yields in the Hart district as it has in previous seasons. Localised frost damage was observed in the district and would have contributed to lower grain yields. The effects of heat and frost stress were not modelled in the predictions presented here.

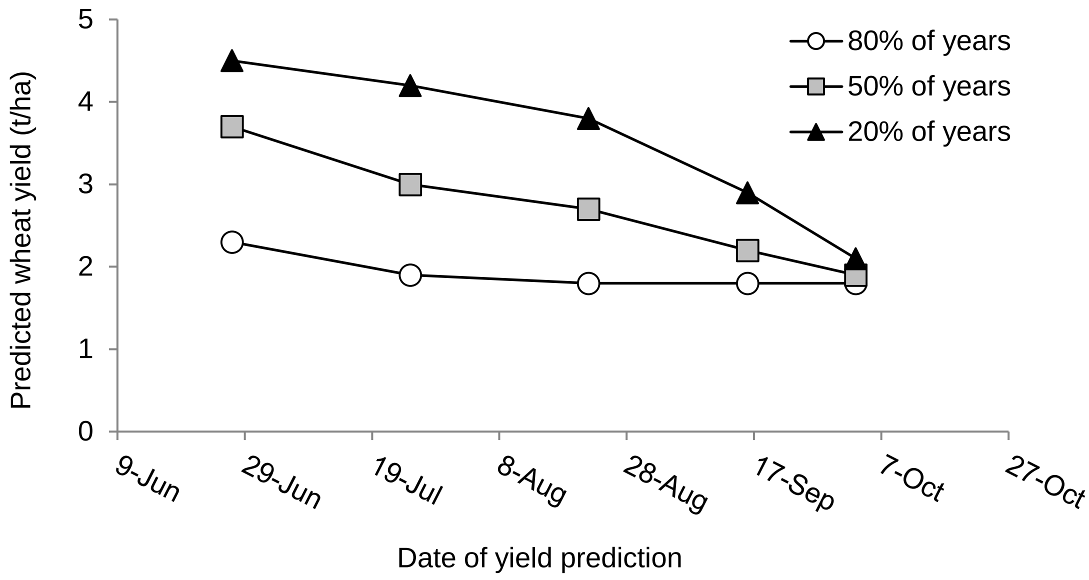

Figure 1. Yield Prophet® predictions from 27th June to the 3rd October for Mace wheat sown on the 1st May, 2018. 80%, 50% and 20% represent the chance of reaching the corresponding yield at the date of the simulation.

Table 1. Long-term (100-year average) and 2018 monthly rainfall (mm) for Hart.

	Long-term ave. (mm)	**2018 (mm)**	**Difference (mm)**
Jan	19	12	-7
Feb	21	3	-18
Mar	18	9	-8
Apr	27	13	-14
May	44	42	-2
Jun	50	25	-25
Jul	49	20	-30
Aug	48	43	-5
Sep	44	8	-36
Oct	37	9	-27
Nov	27	29	2
Dec	24	9	-14
Total	408	223	

Plant available water (PAW) (0-90 cm) at the beginning of June was low, at 48 mm (Figure 2). This was significantly less stored moisture compared to the same time in 2017 (169 mm). Across the entire growing season PAW did not exceed 50 mm (or 25% of the 'bucket' estimated to hold 200 mm PAW). Plant available water decreased during June and July due to below average rainfall. Rainfall in August kept the PAW level consistent in this month. The soil moisture probe at Hart showed barley roots extracting soil moisture to depths of 80 cm at the beginning of August. From early September the bucket water level decreased to almost empty at the start of October, reflecting the dry finish and signalling an early harvest.

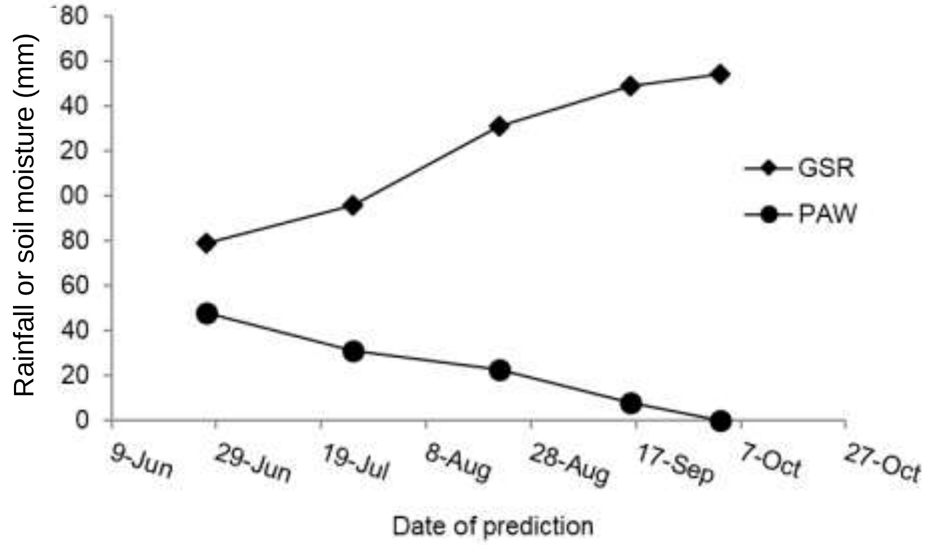

Figure 2. Predicted plant available water (PAW) and recorded cumulative growing season rainfall from 27th of June to 3rd of October at Hart in 2018.

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The *HART BEAT* newsletter, first introduced in 2009, is an initiative of the Hart Field-Site Group.

It is aimed at providing farmers and agronomists with regular updates of current and predicted crop and soil conditions as a season progresses.

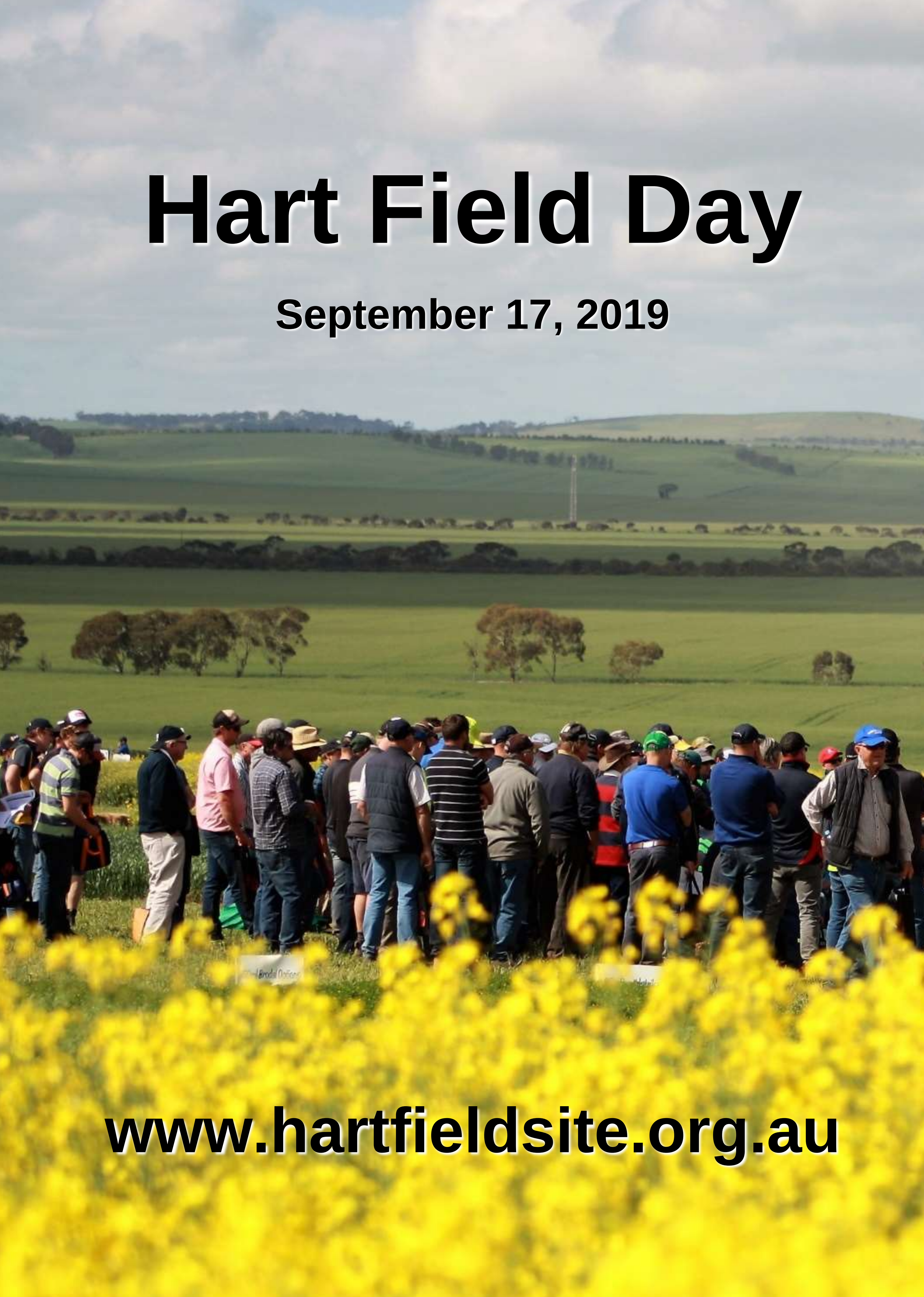
We believe it will assist in making informed choices on the need for additional nitrogen and fungicide applications.

The Yield Prophet® simulations featured are not a crystal ball, but provide a realistic prediction of the available soil water and nitrogen status of your crop.

www.hartfieldsite.org.au

Hart Field Day

September 17, 2019



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Winter Walk 2018

Seeding at Hart 2018

Notes

agfert
Quality Fertilisers

Premium
Cropping Range

DAP ZinCote 1%

Agfert's Premium Cropping Range will consist of a range of products with superior nutrient levels and handling properties to the standard fertiliser range.

Also Available in MAP ZinCote 1%

DAP ZinCote 1% is Agfert Fertilisers first premium compound product to be released as part of its Premium Cropping Range. New technology allows Agfert to get 1% zinc evenly applied to every granule, ensuring even and consistent distribution of Zinc throughout the furrow. The Zinc used in DAP ZinCote 1% is in a controlled release form supplying zinc to the plant gradually throughout the growing season.

Contact Derryn Stringer on (08) 8862 1866
for more information & to work out your fertiliser requirements.